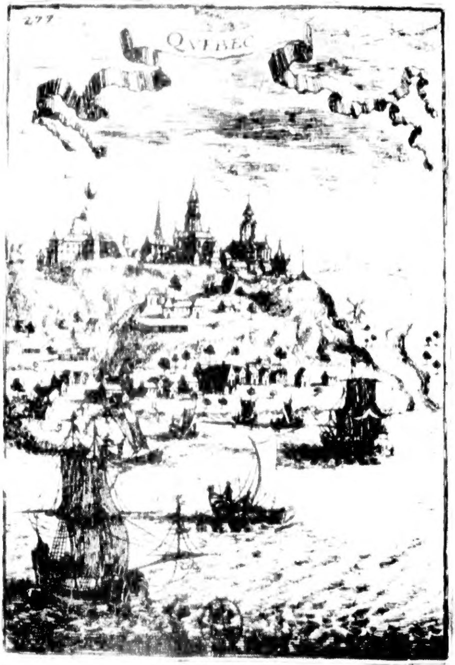
QVEBEC

B

POPULAR TREATISE

ON THE

BEET ROOT CULTURE

AND

SUGAR FABRICATION

IN CANADA.

"Travaillez, prenez de la peine,
C'est le fond qui manque le moins."
Lafontaine.

BY OCT. CUISSET,
INDUSTRIAL CHEMIST AND MANUFACTURER OF BEET ROOT SUGAR.

QUEBEC:
J. A. LANGLAIS, STATIONER AND PUBLISHER,
177, St. Joseph St., St. Roch.

1876

DEPARTMENT OF AGRICULTURE AND PUBLIC WORKS.

Quebec, 12th August, 1875.

MR. OCTAVE CUISSET,

Quebec.

Sir,

A copy of the book which you have published under the title of "*Popular treatise on Beet Root Culture and Sugar Fabrication in Canada*" having been laid before me, I deemed it advisable to submit it for examination to Mr. Edouard Barnard, of Varennes, a gentleman well versed in studies of the kind, and you will find, hereunto annexed, his very flattering estimate of your very interesting work.

I entertain the hope that the public will confirm his opinion and subscribe liberally for your book, whose practical working cannot fail to produce excellent results, in view of the establishment of this branch of industry in this Province.

I have the honor to be, Sir,

Your obedient servant,

P. GARNEAU,

Commissioner.

THE HONORABLE MR. GARNEAU,

Commissioner of Agriculture and Public Works.

Sir,

At the request of Mr. Moreau, Secretary of your Department, I have carefully perused Mr. Octave Cuisset's book intituled "*Popular treatise on Beet Root Culture and Sugar Fabrication in Canada.*"

This work, which is easily read, gives very exact information on the culture of the sugar beet and its manufacture. It is of a nature to popularize among our farmers this industry, which, if established permanently, cannot fail to regenerate our agricultural system.

I have the honor to be, Sir,

Your obedient servant,

ED. A. BARNARD.

INTRODUCTION.

The idea of introducing the manufacture of beet-root sugar into Canada, has during the last few years, deeply moved the canadian public, and assuredly nothing should more attract the attention of an essentially agricultural people.

Not only would its manufacture be a source of profit to those engaged in it and a boon for the working classes, but the general cultivation of the sugar beet would necessarily introduce most desirable improvements in the agricultural system of the country.

In publishing this small work, I wish to convey in the first part of it, information to farmers as to the manner best calculated to succeed in cultivating this plant, and in the second part I will explain the principles upon which the sugar is made.

In writing it, I endeavored specially to make myself understood by all who are able to read.

It is now by experience incontestably shown that the soil of Canada is favorable to the culture of the sugar beet. The numerous experiments made in various parts of the country have sufficiently shown that with a good system of cultivation 15 or 20 tons of beets per acre or 600 to 800 bushels, the ton con-

taining 40 bushels, could be easily raised. This alone would be sufficiently remunerative to satisfy the ordinary requirements of agriculture, even if no other results of the greatest importance to its future progress, should arise therefrom. But it is not enough that the quantity should appear sufficient : for agriculture to be productive and satisfactory the quality must equal the quantity, and that it should produce for the sugar manufacture a raw material possessing all the requisites necessary to be truly remunerative in its subsequent making up. In fine, the beet should contain a sufficient quantity of pure sugar to permit of its economic extraction ; and in this view again, there can be no doubt as to the excellence and saccharine richness of the beets raised in various parts of Canada, as well in the Province of Quebec, as in Ontario. I will say further : That they have been generally found to be most uncommonly rich. Thus, whilst the juice that I had before observed rarely exceeded 7 degrees Beaumé and never more than 8°, or 5°, 11 to 5°, 88 centissimals or again 12°, 61 to 14, 42 Brix, it has been acknowledged that the juice of the canadian beet generally marked 9° Beaumé, say 6°, 67 centessimals or 16°, 24 Balling, which is a maximum that has been rarely met with in any country.

It is to be understood that I am here speaking of sugar beets which have been cultivated according to a good system and in suitable ground ; and which were sown in proper time and were not taken up until fully matured.

For the perfect understanding of what I write, I must here speak of areometers and explain what I mean by *degrees Beaumé*, *degrees Centessimal* and *degrees Brix*: in ordinary practice to ascertain the value of a sugar beet, it is scraped, the pulp is pressed and the juice gathered and then *weighed*. To weigh the juice, there are several instruments in use, which when plunged into liquid show its strength, as they sink more or less into it. These instruments with which no doubt many are familiar, but which the majority have never seen, are called *areometers*. To ascertain the value of the juice of the beet three kinds of areometers are used: the first, the Beaumé areometer whose graduation is somewhat arbitrary; the second the centessimal areometer, generally used in France and Belgium, indicates directly the density of liquid and consequently its specific gravity; lastly, the third, that of Balling or of Brix, specially designed to weigh solutions of sugar in water, shows directly by its graduation the quantity of sugar in any watery solution of this nature, either the juice of the beet, or cane or the sap of the maple.

It is easily seen that the latter is the most useful for the subject which occupies our attention, but as it can not always be procured, whilst the Beaumé areometer is known and sold every where, it is easy, by the use of comparative tables and simple calculations, to arrive at the degree upon one of these areometers, given the degree which a liquid marks upon the other. Thus, I find either by the

tables or by calculation, that a juice which marks in the Beaumé areometer 7°, 8°, 9°, respectively, ~~marks~~ on the densimeter 5°, 11, 5°, 88, 6°, 67 and on the Brix areometer 12°, 61, 14°, 42, 16°, 24.

Aided by the figures just given and the table which I give on page 89, those who cultivate the sugar beet may ascertain the industrial value of their crop.

If therefore you have cultivated the sugar beet and wish to ascertain its industrial value, you must take one root of the average size, or two roots one large and one small, and scrape them in the direction of their length, so that if you do not scrape the whole beet, the pulp shall have been taken equally from the head, the middle and the point. This precaution is necessary to obtain a juice of the average richness, for all parts of the beet are not equally rich in sugar; in fact it is well known that the upper portions are poorer in proportion as the collar is neared. This done, you place the pulp in a press and you press it as much as possible; you catch the juice in a deep and narrow vessel and plunge in your *juice weigher*, say the Beaumé areometer: the point of contact being noticed, you establish the degree. Suppose you find 8 degrees and a half; you wish to have the Brix degree, the most rational of all, you find in my table that 8° Beaumé corresponds to 14°, 42 Brix and that 9° corresponds to 16°, 23; between 14°, 42 and 16°, 24, there is a difference of 1°, 82; halve this difference and add the half 0.91, to 14°, 42 and you have 15°, 33 Brix corresponding

to our 8° and a half degrees Beaumé. That is to say if the juice of the beet experimented upon were a solution of pure sugar in water it would contain, for a hundred pounds of juice, 84.67 pounds of water and 15.33 pounds of sugar; but as will be afterwards seen these 15.33 pounds of matter in solution in the water contain in addition to the sugar a variable quantity of foreign substances, sometimes as much as 25 and even 30 per cent, so that the absolute richness in sugar of our juice, at the rate of 75 of sugar for every 100 of matter in solution, comes to be 11 pounds and a half of sugar per 100 pounds of juice. If we wish to know from these data the total quantity of sugar contained in the beet, we would admit what experience has shown to be the case, that the beet contains 96 per cent of juice, although in its manufacture only 80 per cent is utilized and by multiplying the quantity of sugar in 100 pounds of juice by 96 we would have in our case 11.04. I think these data are sufficiently complete, and it will be sufficient for me to add that when a beet yields juice reaching 9° Beaumé it is considered to be extremely rich, deduction being always made of all physiological circumstances that might accidentally tend to disadvantageously modify the ordinary nature of the juice; a beet yielding a juice of 8° Beaumé is very good; that yielding a juice of 7° Beaumé is used with advantage; whilst beets yielding a juice of 6° or less are unfit for manufacturing into sugar, not because sugar cannot be extracted from them, but because the cost of manufacture would be too high in proportion to the results obtained.

To arrive at strictly accurate results, we have only to rely upon chemical analysis to give complete satisfaction. But it is not my intention here to give methods of chemically analyzing beets or juices, this would necessitate entering into details of too complicated a nature for a work such as the one that I intend to submit to the public. It is sufficient if each will be able approximately to estimate the industrial value of his crop, and I think, as I have already stated, that those who read my work with some attention will be able to make the necessary experiments for themselves in a sufficiently accurate manner, without having recourse to tedious chemical processes of difficult study and comprehension.

HISTORICAL NOTICE.

The manufacture of beet root sugar, one of the finest and most important inventions of modern times, is a project of the nineteenth century, so fertile in great discoveries. Although the presence of sugar in the beet had already been known, it remained for this age to commence its extraction as a manufacturing industry, and it was reserved to France, the agricultural country *par excellence*, to be the first to commence this new industry.

The establishment of beet root sugar factories arose entirely from political causes. In 1806 the Napoleonic sway had reached its highest. By his successive conquests he had acquired a formidable empire, of which the other states, Spain, Prussia, Austria and even Russia were only as it were the satellites; one power alone counterbalanced that of the great emperor and seemed to defy him, even in the midst of his unheard of glory; the English government was the irreconcilable enemy of the glorious continental despot. Often had Napoleon gathered formidable armies together to carry the war into the territory of his uassailable enemy, whose influence he everywhere felt, but his enemy always baffled his efforts. The emperor understood that he could not conquer her, except by attacking her in

the source of her power, her commerce. This was in fact England's vulnerable side, her immense colonies and innumerable manufactures supplying the world with innumerable quantities of fabrics. The *continental blockade* was decreed and the conquered powers were obliged willingly or unwillingly to submit. By this treaty the entry of all raw or manufactured goods, coming directly or indirectly from England or her colonies was rigorously excluded from all European ports.

This measure caused an extraordinary development in the various manufacturing industries of the continent, and gave rise to several new industries, such as that of artificial soda and of beet root sugar, which have been abundantly successful. Napoleon especially encouraged the latter, by generously rewarding all efforts made to establish it. From that time it has unceasingly prospered, and has now spread over all the countries of central Europe.

It will suffice to read the following figures to show the importance of this enterprise, which has risen within the last century.

PRODUCTION OF BEET ROOT SUGAR IN FRANCE.

1825	5,000	tons.
1836	40,000	"
1852	68,000	"
1862	170,000	"
1868	275,000	"
1872	300,000	"
1874	350,000	"

I here give a table showing the state of Beet root sugar in Europe in 1866-67.

TABLE *showing the Production of Beet Root sugar in Europe in* 1867.

	Number of Factories.	Sugar produced tons.	Product. of each fact'y tons.	Number of acres under cultivation.
France....	434	216,854	499	180,000
Germany..	296	202,850	685	170,000
Austria....	140	76,164	544	75,000
Prussia....	259	149,000	575	120,000
Belgium...	120	60,000	500	50,000
Holland...	18	5,000	355	5,000
Poland....	41	11,250	276	10,000

I have no data to show the present state of the industry; I only know, that in France there are 600 factories and that 350,000 tons of sugar are made, that in Belgium there are 200 with a production of 100,000 tons; and that the other producing

countries have since increased their amounts by 50 per cent at the least, so that the present production of beet root sugar in Europe is :

For France	350,000	tons.
" Belgium	100,000	"
" the other countries	600,000	"
Total	1,050,000	tons.

PART FIRST.

—

BEET ROOT CULTURE.

§ 1°. Choice of Soil.

The beet may be cultivated in the majority of soils which produce cereals; but the most favorable places for its culture are vegetable moulds, rather sandy than argillaceous, deep, friable, soft to the touch, warm, active, without stones and permeable. The greater part of the soil of Canada fulfils these conditions and is especially adapted to the culture of the sugar beet; it is in fact formed of alluvial deposit or of argillaceous and calcarious earths in favorable conditions.

Alluvion soils are the best, as well from their composition as from the assimilative nature of the matter contained and which furnishes nourishment to the plants. Beets sowed in such soil come up very well: they give the best return to the farm and a substance of superior quality for manufacturing purposes, provided always that these lands are kept properly manured and drained, and are carefully worked and cleaned. The sugar beet cannot succeed in marshy lands, in which it gives only poor crops. If this plant would grow in such soils and give an

abundant harvest and roots of sometimes large dimensions, still the beet would furnish only poor juice, not rich in sugar and having a great deal of water and foreign substances, which would make it unfit for manufacturing purposes and very difficult to preserve. With such soils, drainage is absolutely necessary to render the soil fit for beet culture.

Argillaceous soils are also very well fitted for the culture of the sugar beet, if they are not too compact and the sub soil permeable. These soils are in good condition when with the clay they have a sufficient quantity of sand.

For rich lands about......................	50	per cent.
For sandy soils with clay basis.........	60	"
For clay soils with sandy basis........	75	"

When these soils drain easily, whilst retaining a certain amount of humidity, have a vegetable coating sufficiently friable, are easily worked and do not get a solid hard crust in dry weather after rain, they generally give an abundant crop of good quality. This is not the case with soils in which clay predominates; these soils are heavy, compact and dried up and get into cakes which are very difficult to break. The drills are not easily made and the seed often fails. When properly cultivated and in a favorable season these lands, however, give larger crops than argilacious sandy soils; but altho' they need not be rejected for manufacturing purposes, still the beets are often of inferior quality. Land of

this nature should be improved as economically as possible.

Calcarous soils are generally remarkable for the fine crops that they yield. The reason is easily given, the beet requires rapid growth, and once germinated, the sooner it arrives at maturity the better it will be. Every thing therefore that tends to quicken its growth would increase the yield. The lime in the soil makes it more easily warmed, more active and hastens vegetation. Consequently, in crops gathered at the same time, we would have from calcarious soils richer beets and those giving a purer juice, than from lands that have no lime. One reason also of this greater activity in calcarious lands is that the lime in the soil hastens the decomposition of the organic substances and of the principal alkalis that they contain, and sooner prepares these principles for absorption by the plant.

There are calcarious soils, however, that are inert, which become unfit for the culture of the beet and in which all other plants equally fade or die. I speak here only of calcarious soils that have in them in normal proportions, the two other primitive elements of the soil, sand and clay, and whose vegetable coating is of sufficient depth and friable, and this is generally the case as well in this country as in all others. Compact slate lands are met with, which at first sight would seem to be unfit for beet culture. To improve these lands and make them fit for this culture they must be prepared.

The greater part of the soil of Canada then, can

be advantageously employed in the culture of the sugar beet, and the facts that I have given are proved by experience, as in several places many experiments have been made in cultivating this plant and very successfully. I would not however advise the sowing this plant in light and shallow soils which scarcely retain the necessary humidity for the growth of the beet; low, marshy, cold lands must not be used in this culture, as in them the beet cannot succeed in its growth.

§ 2° CLIMATIC INFLUENCES.

The beet is a plant which belongs to the temperate regions; it is the *sugar cane* of northern countries. It is cultivated in Europe between latitude 60° and 40° north, and specially between Kiew in Russia and Rome in Italy. It likes warmth and attains a maximum degree of richness and purity under its influence. Thus a temperate spring, with moderate rain at intervals causes its rapid growth; under this influence, the leaves are developed, and soon cover the ground, from which the roots are obtaining nourishment, and, preventing it from drying by intercepting the rays of the sun, they enable the plant to endure without damage the heats of summer. When the leaves cover all the ground the roots then commence to be fully developed; exterior work seems to be arrested, and the work inside acquires the greatest activity, if the temperature is warm and if from time to time the earth is refreshed with moderate but not continuous rain. Whilst expanding,

the beet, at this period, that is during the month of August, is *forming its sugar*, and this is again an important period for the final result. If the beets have grown with favorable surroundings, and the months of August and September are warm and dry but not without some frequent showers of rain we are certain, that with every thing else favorable,our beets will ripen perfectly and will yield juice of great richness and remarkable purity.

We cannot always expect to have such favorable conditions as that I have just mentioned ; they do not happen every year. Does this mean that for the years in which things are not quite so, that the beets will not be good! Let us reject all such notions. In the value of the yield from the earth, there is a maximum and minimum yield, between which is found the average. Crops above the average are considered as good, and as better the nearer they approach the maximum. On the other hand there are, under the average, various degrees more and more unfavorable. Each year will give different returns of beets as well in quantity as in quality. All crops are subject to these fluctuations.

§ 3° PREPARATION OF THE SOIL.

I mean by preparation of the soil, all those mechanical operations which are necessary to adapt it to receive the seed of the beets, to mellow it, and to place the fertilizing principles contained in it, in such a condition that they may be assimilated by

the seed. This work of preparation includes the ploughing of the land in the fall and spring before sowing.

The arable coating should be sufficiently deep and strong so that the roots may descend deeply into it and find new nourishment even down to the subsoil. To attain this end, the land must be ploughed in the fall to the depth of one and one half feet, and upwards. As the beet should find in the soil a certain quantity of alkaline salts in dissolution, the field should be ploughed deeply in the fall and left in furrows; under the influence of the air, the moisture of the rain and snow, and of the frost, the insoluble substances contained in the soil are desegregated and are brought into the state necessary to be absorbed by the plants. This mechanical preparation of the soil is certainly the best method of rendering the soil suitable for assimilation by the plants. The better the ploughing, the better will be attained the end aimed at in vegetation. In the fall care should be taken to plough the same field several time over. The turning over of the soil and the changing of that portion in immediate contact with the air tends to increase in the soil a larger quantity of soluble matter. When beets are to be grown after a crop of cereals, whether corn, barley or oats, as soon as this crop is taken up, the land should be lightly ploughed over to pull up all the straw and uproot all plants still growing. If this is done these plants are prevented from arriving at maturity, to produce seed that would poison the ground the

following year. This ploughing is intended to hasten the decay of the vegetable matter remaining from the preceding growth, which under the action of the air and moisture is rapidly transformed and becomes suitable to nourish the subsequent crop. The roots being thus destroyed, immediately after the harvest, decomposition has more time to become complete and it is further favored and hastened by the still high temperature of the season. During the fall, when the straw, the roots and the plants are destroyed, the land should be ploughed as deeply as possible. This deep mellowing of the soil cannot be too strongly recommended and for beets in particular it seems to give the best results. The moisture after penetrating this ploughed strata can not afterwards evaporate as easily ; it is stored in the soil and forms a reserve whose future action, in dry seasons is very necessary for vegetation. In dry seasons the plant will draw up by its roots from the sub-soil the moisture not to be met with in the layers nearer the surface. The bases of the arable coating thus become a permanent reservoir of moisture ; at the same time being a protection against changes of temperature, for after rain it absorbs a much larger quantity of water than the soil which had been only superficially ploughed. Lastly, general experience has shown that deep autumn ploughing is of the greatest advantage to the growth of the beet and its influence is specially efficient during dry seasons.

In countries where the soil has never been cultivated except to a very small depth, and in which

the rotation of crops does not allow of deep ploughing every year, it would be well to break up the sub-soil with a sub-soil plough, so as to mellow the lower courses without mixing them with those of the surface, richer in manure.

During the winter the furrows made by the plough are left open. The frost tends to break up the cakes ; the water from the rain, which has filled all the small pores of the mass expands in freezing and reduces the earth to dust. Thus is obtained a pulverized mellow surface, perfectly prepared for the reception of the grain whose particles will surround the seed and favor its growth.

From what we have said, it is certain that good ploughing at proper seasons, notably tends to increase the nutritive qualities held in solution in the earth. Such ploughing really takes the place of manure and is thus true economy. A well ploughed field may, with less manure, yield as much as a field badly ploughed but better manured; or which is the same thing, being equally manured the yield of a field will be so much the better if the plounhing in the fall has been carefully and properly done.

By burying the straw in the fall, the soil is rendered more porous and mellow and thus it facilitates the necessary circulation of air and moisture. Organic substances remaining from the preceding crop or brought with the manure, are decomposed in the soil. The gas which they give off causes a certain degree of fermentation which contributes to the mellowing of the ground. Each straw and root

when decomposed or putrified leaves a canal through which the air penetrates to forward decomposition in the lower str .ta.

Formerly, the fields in which beets were intended to be sowed were worked over several times, either with the spade or hoe. Ploughing is a more certain and rational operation and the only one that can be employed in working to any great extent. Here, as every where, machinery is better than hand labor, which is always more expensive. The plough is adapted to all agricultural labor and is more efficient than unskilled hand labor in opening up the soil regularly and to a constant depth. If required, the land may be alternately ploughed across its length and breadth and the soil thus equally mixed. The rapidity of the work, due to the use of the plough, allows a larger surface of ground to be prepared, an essential condition for beet culture.

It will be seen by that which precedes what are the advantages to be derived from careful ploughing in the autumn, and the influence it has upon the growth of the beet. Its influence is none the less felt upon other crops, raised from the soil under a good system of rotation. The earth contains an inexhaustible quantity of substances adapted to assist the nourishment of plants. To be assimilated, these substances must become soluble and everything that tends to this end, will increase the immediate richness of the soil and render it capable of returning a maximum yield to the farmer. Land is capital, real capital, unvarying capital; cultivated in any

way, it will give interest of some sort; but we must not be content to receive interest of some sort, if by earnest work this capital may be made to yield two, three or four fold, &c. The industrious farmer is amply repaid his efforts by the results he obtains; agriculture and the branches depending upon it are the only really staple industries upon which we can at all times depend. Farmers, love your occupation, cherish your farms, work them and labor upon them, they contain inexhaustible riches, which they will liberally bestow upon you. In this connection I cannot avoid quoting one of the apologues of the great french fabulist, Lafontaine. An old man, on his death bed, speaks to his children:

" Travaillez, prenez de la peine,
C'est le fonds qui manque le moins.
Un riche laboureur, sentant sa mort prochaine,
Fit venir ses enfants, leur parla sans témoins :
" Gardez-vous, leur dit-il, de vendre l'héritage
" Que nous ont laissé nos parents,
" Un trésor est caché dedans.
" Je ne sais pas l'endroit, mais un peu de courage
" Vous le fera trouver, vous en viendrez à bout.
" Remuez votre champ dès qu'on aura fait l'août :
" Creusez, fouillez, bêchez, ne laissez nulle place
" Où la main ne passe et repasse."
Le père mort, les fils vous retournent le champ,
Deça, delà, partout ; si bien qu'au bout de l'an.
Il en rapporta davantage,
D'argent, point de caché, mais le père fut sage
De leur montrer avant sa mort.
Que le travail est un trésor."

"Work, do your best, the farm is the only thing which will not delude you."

A rich farmer, feeling that he was about to die, called his children to his bedside and spoke to them in private.

"Do not said he, sell, the inheritance which has come to us from our ancestors: a treasure is hidden therein. I don't know the exact place, but with a little courage, you shall find it; Work up your field immediately after harvest turn it over, search into it, dig into it, leave no place unturned."

When father died, his sons plowed and worked the field here and there and every where, so much so that at the year's end, it yielded a large return. Of money none was hidden, but the father was wise in teaching them before his death, that labor in itself is a treasure.

I will not comment upon this apologue, it is easily understood by any one that reads it.

I think that I have sufficiently enlarged upon the preparatory ploughing in the fall. I must now speak of preparing the ground in the spring for the seed.

Generally the harrow and roller are solely used in preparing the soil for the seed, and this with a view of retaining in the soil all the moisture possible. This method, however, is not sufficient unless for highly cultivated lands. In other places, the winter furrow is first smoothed by the harrow or roller. The cakes are as much as possible broken and smashed, then the ground is grubbed and harrowed. The sowing then takes place and the land is afterwards rolled.

But in fields, in which noxious weeds are easily produced, a light ploughing would be the best means

of causing these parasites to disappear. It would also mark out more mellow ridges for the seed. It is true that by so doing, the land would through the invariably dry winds of the spring lose a great portion of its moisture ; but one fall of rain will restore the soil to its normal state of moisture. From the more rapid growth thus secured to the beets the weeds are killed off by them, and a more abundant harvest is assured. A multiple share plough which would give a smooth surface for the seed could be advantageously employed.

In terminating this section I will give a general rule, which should always be a guide to farmers.

The land must be worked as well before as after having been sown, BUT IT MUST NEVER BE WORKED EXCEPT WHEN DRY. *All work in land when it is wet is more hurtful than useful. The ground cakes and becomes compact, instead of mellow and remaining subject to atmospheric influences ; and the growing plant entrusted to it can only grow under unfavorable conditions.*

§ 4. Rotation of Crops.

Rotation is the system which determines the succession of crops in a field.

The choice of a good system of distribution or rotation is of vital importance to agriculture and it is especially necessary when the sugar beet is extracted. The object of rotation is so to arrange the crops that each shall draw from the earth the substances necessary for its growth and under the most

favorable conditions. If all plants draw from the earth the same elementary principles they do not draw them in the same proportions nor in the same combinations, and their regular succession allows each in its turn to draw the nourishment best fitted for it. Every one knows, without it being necessary for me to explain, the little advantage to be gained by cultivating the same plants in the same fields for several years in succession : the land soon loses all the substance required by the plant and the crops gradually grow less and less. It can hardly be objected that in uncultivated lands we see indefinitely reproduced, with equal strength of vegetation, plants spontaneously produced, for we can find in their very diversity a simultaneous rotation which prevents the destruction of the equilibrium of the soil. In a good system of rotation, care must be taken to take a natural order, that is to say the preceding crop prepares and gives way to the succeding one.

For example beets require a clean, mellow, and deep soil : to have clean soil, for any given year, a plant must be cultivated the preceding year, which by its vigorous growth has choked the greater part of the weeds or which has allowed them to be destroyed by being cut before their seed has arrived at maturity.

A rotation of three or four years is often followed.

In Europe, I have often observed the following four year system.

Rye or corn,
Beets,
Spring cereals,
Clover with dressing in autumn.

Clover is sown in the spring of the third year and dressing is applied in the fourth year for fall ploughing. Here in Canada, the three year system might be adopted as follows :

Rye, oats, potatoes,
Fodder plants with dressing,
Beets,

or

Fodder plants with dressing,
Corn, rye or oats,
Beets.

This latter mode would perhaps give smaller crops, but the beets would generally be better.

When dealing with very rich lands, a beet crop must always be preceded by a crop of cereals, and the land must not be manured between them if it is desired to secure good beets giving excellent juice. The crop of the preceding year is in itself a sort of dressing. That which is left in the soil, the straw for example, is buried in ploughing, and when decomposed gives its elements to the new generation of plants that are developing. It is thus easily understood that a good system of rotation is important in cultivating the beet, which in great measure profits by the quantity often large of the various leavings of

anterior crops. The more numerous these leavings and the more they bring organic matter in decómposition to the earth, that is to say the more manure, the more do they assist in mellowing the soil and giving to it a greater adaptability to be influenced by atmospheric changes. But although important, the advantages of a good system of rotation in producing sugar do not end here. Preceding vegetation also serves to extend and dilute the nutritive elements of the soil and thus improve the beet.

§ 5º MANURE.

It would be superfluous in the present state of agriculture in Canada, and within the confined limits of such a treatise as the present, to speak of the infinite number of manures both natural and artificial that are in use in the old countries of Europe. In these countries, where for a long time agriculture has been forced, very many substances have of necessity been used to return to the earth, those principles which are annually taken from it by the crops to prevent its being exhausted. Canada has not yet arrived at this state ; its soil is naturally rich and abundant, and it will be sufficient for the farmer, at least at present, to plough his land carefully and collect such manure as he can. It would be only advantageous to him to increase the number of his cattle, to produce a larger quantity of manure. It it not many years since, in the countries in which I for a long time lived, agriculture was not obliged to make use of all those manures more or less

artificial which are now sold; it had only to learn how to make a profitable use of all the riches which were being lost every where on the farm. Within reach of the farmer there were numerous precious substances which they have learned to collect with the greatest care. As soon as there was need he endeavourd to increase these substances. Cattle had heretofore been only considered from a commercial point of view, they were soon to be considered as a factory for manure and they were increased as much as possible. The old useless and even hurtful fallows, nurseries of seeds of hurtful weeds, were replaced by fine crops of fodder plants which served to feed the cattle and improved in place of deteriorating the land. The amount of fodder to be used was increased: the manure, from the stable, was placed in watertight ditches or placed in contact with purin where decomposition set in, and it thus became more suitable to give up in a shorter time its nutritive qualities to the plants. The stale was directed to these manure heaps to increase their value, or collected in separate cisterns to be distributed over the natural or artificial grass lands. All the stray and hurtful farm rubbish was gathered together and mixed with lime to form valuable compost, to be applied, in the fall, upon the fields being prepared for the culture of the beet or in the spring upon artificial grass lands.

Under the influence of these improvements agriculture soon attracted to itself large capital, and when the time came that the land required an increase of manure, which was not just at hand,

the farmers were enabled to produce the necessary funds for its purchase.

Thus, as I have said, the canadian farmer in the mean time need only turn round to find about him a valuable and sufficient source of riches, for his present use and future enjoyment. Let him work his fields carefully, not lose any sort of manure, let him increase the quantity of manure within his reach and make a judicious use of what he has, let him adopt a good system of rotation, and if he is active, careful and economical, I may guarantee that he will not long fail to enter upon the road that leads to fortune. Let him attach his son to the farm, it is better for the son to remain a farmer than to vegetate in large towns, there to lose the love of his family, the habit of working and spend a life often useless both to himself and to society.

The principal manures that we have at our immediate disposal are green and stable manure.

Green manure has been employed at all times and in all countries; it consists in plants that are allowed to grow and are afterwards buried in the earth. In North America red clover is not mowed, it is merely buried as a manure. In this country maize is often repeatedly grown on exhausted lands for the same purpose. The green plant is each time buried in the soil with its leaves and thus makes more manure for the land. In France, England and Belgium, buckwheat, vetch and theafter growth of clover, &c., &c., are used for the same purpose. These crops are buried when just about to flower.

The warmth of the air and soil tends to the rapid decomposition of these organic matters full of sap which spreads more evenly through the land than any other manure and brings to it a rich provision of nourishment gathered for the most part from the atmosphere.

Green manure in being transformed in the soil gives rise to such gaseous products, as ammonia, carbonic acid which can be almost entirely absorbed by the land, whilst the decomposition of nearly all other manures is attended with serious loss.

These gases retained by the moisture of the land afterwards give nourishment to the plants.

Green manures are specially advantageous for beets, as they do not burn and do not introduce into the root any excess of matter which might tend to prevent the extraction of sugar. In the interests of the manufacturer, we value the beets grown with green manure at a higher rate than those grown with any other manure.

Green manure may be advantageously employed in sparsely settled countries, in which there is a great quantity of land at disposal, because it avoids expense in labor and cartage.

This manure may be also used in conjunction with stable manure ; manure is often spread over the plants before they are buried.

Green manure produces the same effect as would the manure of a herd of cattle who had consumed three times the amount of fodder.

Stable manure is the most used. It contains nearly all the elements necessary for ordinary farming, which the crops take from the soil. For beets, a fresh dressing of this manure gives a more abundant crop, but the juices of the roots are less pure and more charged with organic and mineral substances which prevent the extraction of sugar; it is therefore in the interest of manufacture, better to raise one crop between the fresh dressing and the culture of the beet, either a crop of corn, rye, barley or oats.

The manure, before application, must be kept in such a way that it shall not become heated or dried up, so that all its fertilizing qualities may be retained.

Liquid excrements are an excellent manure easily assimilated. It is estimated that urine has a value equal to five times its weight of good stable manure. To facilitate its preservation and use, it is collected sometimes upon dust or dry earth. A pulverulent and inoderous manure and one very suitable for beet culture is thus obtained.

Lime has a very efficient action upon beets, it fixes the free acids of the soil and prevents their hurtful effects; it also decomposes the insoluble organic and mineral combinations contained in the soil, and makes them soluble and adapted to vegetation. Lime thus revivifies and renders profitable the inert treasures of mother earth, and brings about a more rapid return of capital, a result everywhere regarded as a considerable advantage. Lime is, therefore, for the manufacturer an important means

of securing good beets in as short a season as possible. It cannot exercise a hurtful action even if employed in too large quantities so as to extract from organic substances more ammonia than can be retained by the earth. Lime does not exhaust the soil by prematurely subtracting therefrom, but rather returns to the earth the interest of the dead capital lying enclosed in it.

Naturally lime is only useful when the soil has in it large and undecomposed quantities of mineral and organic substances, and when the land is of itself neither active nor warm enough to extract all these necessary substances without assistance. Lime is therefore a method of assuring the most prompt utilizing of the manure, and it is for this purpose that it is mixed in compost. Lime decomposes organic substances and it is through it that the hurtful decomposition of plants is transformed into fermentation, which is necessary for vegetation.

Lime is used in various ways. Quicklime is mixed with vegetable refuse, cleanings of streams and ditches, and dust from roads. When the lime is quickly slacked, it is mixed as much as possible with the other matters by moving the mass with a shovel. This manure is applied to fodder crops in the spring or on the same crops in the fall before ploughing ; or, and very advantageously, upon the fields in preparation to receive the seed of the beet Sometimes small heaps of lime are made regularly in the fields and they are covered with a few shovelfulls of earth, and when the lime is slacked

it is spread over the field. This method is applied to the fields under cultivation and specially in the spring before sowing beets. The lime also is finally slacked in a covered place and it is spread indust over the field which is to be or has just been sown.

The quantity of lime to be used per arpent is generally from 4 to 5000 pounds or about 40 bushels.

§ 6. SOWING THE BEET.

All beets contain sugar, but all cannot be advantageously used in the manufacture of sugar. In fact the beet which is generally cultivated for cattle cannot be used in manufacture. In addition to containing only a small proportion of sugar, it contains in greater quantities albuminous matter which itself is antagonistic to the extraction of sugar. The presence of this foreign substance would not make the beet unfit for distilling purposes, but it cannot be employed with advantage for this purpose on account of its scarcity in sugar,and consequently its poor return in alcohol. Thus, as I stated in the introductory portion of my work, beets to be suitable for manufacturing into sugar, should contain a juice which will show a strength of at least 7 degrees on the Beaumé areometer ; and further that these juices must be sufficiently pure, so as not to hinder the extraction of sugar.

In the manufacture of sugar several kinds of beets are cultivated, the chief of which are :

The Silesian beet with the rose collar.

The Silesian beet with the green collar.

These beets are originally from Silesia, an eastern province of the Kingdom of Prussia. They are most generally cultivated in Belgium and France. They are the richest in sugar, their tissue is firm and they are better able to resist the influences of cold and the like, and the firmness of their tissue permits of their being easily kept. I have always seen this kind used. I have known some farmers and manufacturers to prefer the rose collar and some the green, but their preference did not seem to me to be based upon any industrial advantage. The yield of the one cannot be considered to be better either in quantity or quality than that of the other. For my part, both for growing and manufacturing, I have always preferred the green collar, and I must admit that I can find no reason whatever to justify my choice. Some however think that rose collar beets are apt to degenerate, but no positive experiment has given rise to this opinion. It would also appear that green collars are better able to withstand frost, but this again is a very rash assertion. However, farmers often sow both separately and sometimes mixed half and half. The reason for this mingling, whose necessity is not very apparent, seems to be easily explained, that influences might arise which would be contrary to the one and not affect the other, and thus a good crop would be obtained at any rate.

Beet seed consists in a hard envelope which contains several small germinating seeds, sometimes 3 and sometimes 5. Each small seed is made up of

the germinating particle and another substance to serve as the first nourishment of the plant, the fecula. When the seed is exposed to moisture for a certain time, the envelope is softened and the moisture reaches the germ itself. Under the influence of this moisture the germ swells and bursts the envelope, the fecula is gradually transformed and is the first nourishment of the germ, as milk is the first nourishment of mammals. During this time, the germ develops and the root shows itself and is soon enabled to draw from the earth the nourishment suitable to it. Two small leaves are then noticed making their appearance and the root descends vertically into the earth. When the two leaves appear, the root has attained a length of about 2 inches. This root develops very rapidly and soon, after one or two weeks, the leaves are strong enough to assist the growth of the plant by a sort of breathing or respiration of the air.

The influences necessary for germination are air moisture and moderate heat. If one of these influences is absent the seed cannot germinate, or if it germinates, vegetation languishes and the germ will soon die. Thus you may keep the seed in dry air and in any heat, without it ever germinating ; a too low temperature prevents germination. For as a seed can germinate in vacuo or in water, although apparently deprived of air, it does so, be cause water always contains to a greater or less degree a certain quantity of air, and the vacuum could not have been altogether absolute, so that a

small quantity of air must have remained, sufficient for germinating the seed, but which in a short time is insufficient for growth and the young plant soon languishes and dies.

At first heavy moisture does not seem to hurt germination, but if prolonged the plant is soon seen to wither. Too great heat would prevent germination and growth: both heat and moisture must be within the ordinary natural limits.

Some seeds of plants retain their germinating power for many years, others again lose it in a very short time. Beet seed for example germinates less quickly at the end of two years, and becomes more and more slow until it at last loses this power altogether. In this connection I will mention what occurred to myself as an example which those who intend to undertake the culture of the beet may profit by: it happened in 1869 in Belgium. I then managed a factory in the province of Hainaut and had to supply seed to sow 600 arpents of land, the contracting farmers being obliged by their agreement to use only the seed furnished to them. The quantity of seed required was about 8000 lbs., say 14 lbs. per arpent. I had grown on account of the factory the seed required; but I had 200 lbs. remaining over from the preceding year which I intended to supply to these farmers whose land seemed more adapted to hasten germination, or which were early ready for the seed. I was moreover certain from experiments made that the seed had in no way lost its germinating quality. But

during an absence of a few days, one of the factory hands, whom I had entrusted to serve out the seed to the farmers, mixed this seed with an equal quantity of the new seed. The error was irreparable, as the seed had been delivered before my return. I took note of the farmers to whom it bad been delivered and observed the consequences: a portion of the seed, undoubtedly the new, came up in ten days, and every one, except myself was surprised that the plants were so far apart: eight or ten days afterwards however the balance of the seed sprang up. Unless under favorable climatic circumstances this would have caused great inconvenience, but nothing came of it, as on thinning out sufficient plants were found to cover any vacancies and the crop did not suffer. However the case seemed to me of sufficient importance to put me on my guard in the future against its repetition. I must also warn my readers against such an inconvenience. They must endeavor to secure seed grown the preceding year or at least not more than two years before; and specially if they have seed of two different years let them take care not to mix them, but sow in different fields the seeds of different growths, and place the oldest in the most active fields and in those that are soonest sown.

On this subject of seed I would ask those who are engaged in the culture of the beet not to neglect trying it first. For this purpose, before sowing, a small box with proper earth is placed in a room and a certain number of seeds, carefully counted and at

proper distances are placed in it. If after ten or fifteen days this seed has for the most part sprung up, it may be concluded that the seed is good ; but if after three weeks the seed has not sprung up, it would be hazardous to make use of it, and it would in such case be better to lose the seed than risk the crop. The temperature of the room in which the experiment is to be tried should be from to 60° to 70° Farenheit.

Beet seed is sown when the earth has become sufficiently warm, has reached from 50° to 54° and when the later spring frosts are no longer to be dreaded. This sowing takes place in France during the later part of April and the month of May. It would be about one month later in Canada. As I have already stated, as soon as the fine weather commences in the spring the land is prepared by superficial working, so as to make the top soil very fine, a harrow and roller being used for the purpose *I must again insist that in no case must the land be worked, for this purpose, unless dry.* The sowing is then proceeded with, also in dry weather. When sowing is done by machine 14 pounds of seed per arpent are required ; this quantity being reduced to 8 or 10 pounds if hand sowing is used. Some farmers sow beet seed as it is, without any further preparation ; others with a view of hastening germination use certain preparatory processes, so as to make the seed have more vigorous germs and to preserve the seed and young shoot from the attacks of insects.

If good beet seed is sown in soil well prepared,

that has a natural temperature of from 50 to 54°, it will take 10 or 15 days to spring up, but this time may be shortened by one half, if the grain before sowing is exposed to suitable moisture and an equal temperature. If the temperature is increased to a moderate degree not exceeding from 65° to 68° during this preparatory operation, the time required for germination may be further shortened by two or three days.

Steeping the seed in water at 65° causes inconvenience, as the water carries off from the seed certain soluble substances necessary to it; but this is no longer the case if it is streeped in urine or purin at the same temperature, which instead of abstracting nutritive qualities, impregnates it with fertilizing principles; and it has been noticed that plants from seed subjected to this process are from the very first, much stronger and more capable of resisting the contrary influences that may arise. Another advantage is that the employment of purin prevents the drying of the seed if a short time only elapse between the operation and the sowing.

A good fresh seed, soaked in purin at 65° during 3 days and afterwards sown, rises in 5 days or at the most in 7 or 8 days. But the great advantage of this preparatory process is that it gives special energy to the growth, more particularly during the first fortnight, and it is thus of the highest importance; in fact at its first appearance, the plant is very delicate and may easily be injured by insects, or changes of temperature and it is absolutely essential

that it should in as short a time as possible, acquire sufficient strength to resist these influences. The importance of this proceeding being thus shown, it is performed as follows :

The seed is steeped for 48 hours in juice of manure, and afterwards kept damp for two or three days in thin layers of 4 inches(in sacks for example). In this way it remains without heating five days at a temperature of from 60° to 65°.

As an example of the effect of this system, I will cite one instance : the same sort of seed prepared and unprepared had been sown, otherwise under identically the same conditions; on the 12th april the unprepared seed and on the 18th those that had been prepared. The prepared seed sprang up on the 26th april, that is to say at the end of 8 days, and the unprepared on the 2nd may, that is to say, at the end of twenty days, say a difference of 12 days.

If prepared seed is employed, care must be taken before sowing, to mix it with dust, so that it may pass through the machine easily.

Whether prepared or unprepared seed is used, it must be sown.

The soil has received all necessary preparation, and presents a well evened surface of fine earth, free from lumps, in fact it is ready to receive the seed.

The time for sowing cannot be fixed by absolute rules, for each region and each year even, special circumstances arise which may modify the choice

of the time. As I have above stated, as soon as the land is sufficiently warmed and the later spring frosts are no longer to be dreaded, the sowing must without further delay be commenced.

Beets are sown in clusters, or in ridges or furrows, by the hand or machine. Let us first notice hand sowing which can only be used in farming on a small scale.

There are two methods of proceeding: In the first, we commence by laying out the field by tracing either with a pallet or tambour, drills that cross one another. The points of intersection mark the places in which the seed is placed.

It is to be noticed that the most suitable depth is about one inch. The distance between the drills should be from 12 to 18 inches. Several seeds are placed in each place so as to ensure success.

In the second process, two parallel cords are stretched from the extremities of the field with knots to indicate the divergence of the lines. Between these two cords are placed other threads at right angles, also with knots showing the places in which the seeds are to be sown. The farmer makes a hole in these places in which he deposits several seeds, 4 or five, and covers them over with a little earth, lightly pressed down.

This process is called cluster sowing. The seeds thus sown together spring quicker on account of the heat generated in germinating. The young shoots are better able to resist the night chills, and give a

sufficient provision for the insects, so that at least one plant w[illegible]main and the harvest be thus assured. H[illegible]r there is one inconvenience, that is, the yo[illegible]oots often get entwined together and on being t[illegible]ned out, they are liable to the danger of being uncovered.

But I repeat that hand sowing is suitable only for restricted operations at the best, and the use of mechanical sowers is a necessity, if beet culture is to be at all carried on, on a reasonable footing. At any rate the work done by the machine is more regular than that done by hand, even when most carefully performed. The sower always deposits the seed at an equal depth, which is very important in regard to the regularity of the crop, and further its use is more economical.

A great number of mechanical sowers more or less perfect are in use.

A few days after putting in the seed, when the land is sufficiently dry it is passed over with the roller. The top soil is rendered smooth so that it covers the plant better, which insures the success of the sowing. The roller again makes the surface more even and consequently the isolation of the plants is better secured and each root can thus sprout separately.

Sowing by machine is generally in uninterrupted lines, that is to say the seed is deposited all along the line.

When the seed has missed in certain places and

there are vacant spaces, these are filled by planting in young shoots when setting out and even afterwards.

Note.—The distances between the drills of beets are from one foot to eighteen inches. The lesser distance for very rich lands, and the greater for those less rich. In general 15 inches is the distance in use. The distance between the beets in the drills is from 8 to 10 inches and the rule is governed by the same circumstances as for the drills. The reason of the rule of greater or less distances as the soil is poorer or richer is, that the root increases on account of the richness of the soil, and the space left each to germinate, so that with the same distances a rich soil would give larger beets. But the larger a beet is in size, the less rich is it in sugar, and the juice contains a larger quantity of water and foreign substances. By diminishing the distances for fertile soils, the beets are forced to ripen in better condition as to size, and the return is not diminished, for if the root is diminished in size there are more of them and of a better quality.

§ 7° Culture of the Beet.

Beet culture, properly so called, includes everything that should be done both to the ground and plant from the time of the appearance of the shoot until its final maturity. It includes the destruction of the weeds, the clearing of the young plants and the various ploughings or delvings which tend to soften and make pervious to the air and moisture, the upper coating of the soil.

The young plants, being elastic and vigorous, soon rise from their confined position caused by the seed and stand upright. Two small and tender

leaves first rise from the earth and seek the light. In favorable circumstances this should accur in 15 days. At this time the sprout and roots are about 3 inches long, in all. The position of the plants is thus easily noticed in the ground, and it is at this time that the *hoe* should be first used to destroy the weeds on their first appearance, and assist the growth of the beet. This work should be very superficial and should not descend further than the thin hard rust which covers the ground, that is to say, at most one inch in depth. In countries densely peopled and where labor is plentiful, it is easy to have this work performed, which is done with great rapidity, by children. But in countries where labor is scarce, it must be omitted. This operation destroys useless plants, which would deprive the beet of a portion of its nourishment and might later on retard its development. However economy here is to be regarded. This work should be attended to as much as possible, but must be omitted if too expensive on account of the scarcity and cost of labor.

When the beet has four or five leaves and has attained a certain strength, it is next submitted to an operation which is called: *mettre en place*. This operation is specially for beets in drills; it consists in rooting out with the hoe, in the drills, useless beets, and in leaving in proper places only two, three or four plants. The spaces between, should be from 8 to 10 inches, and are made with two strokes of the hoe, of an ordinary size. As soon as the *mise en place* is completed the final clearing up is proceeded

with : for this purpose, the plant that appears to be the most vigorous is held in the left hand, and with the right all the others are removed, care being taken not to uproot the plant that is to remain. This should be done in damp weather, so that the plants to be uprooted will come up easily.

Immediately after the separation of the roots, the land is carefully ploughed over so as to destroy all weeds and render it softer. The soil is thus separated and the air more easily penetrates it and gives new nourishment to the roots. This second ploughing, in separating the soil, increases the earths power of absorbing the moisture of the air which penetrates that portion of the soil in which the roots are, gives new principles to the beet and assures a vigorous growth. At the same time the softening of the earth llows a more vigorous growth of leaves and this gain causes more speedy and abundant produc-ion of sugar, for sugar is not secreted until the eaves have attained their full growth.

From this time until the leaves attain their full aturity this operation should be repeated as often possible, due regard being had to economy. Some nes it is twice repeated, at others, three or four nes. The oftener this work is done, the quicker will the growth of the beet. To economise time and bor, machines are used for this work. During the onth of August, when the leaves have attained a fficient growth all work is stopped. The plant n seems to sleep, as it has then no exterior

growth. Up to this time the root will not be a great size, the leaves alone being developed. Now the leaves become stationary and the root rapidly increases in richness of sugar, until complete maturity. I must observe that in the various ploughings and especially in the first, care must be taken not to disturb the earth near the young roots, which if done would cause an increase of the green portion of the head, which contains less sugar than those parts which have not been in immediate contact with the light and exterior air. And here, I will also remark, that the upper portion of the beet, that which rises out of the earth, is always poorer in sugar and more rich in foreign substances than the other portions; the advantage therefore of cultivating a beet whose head rises little above the earth is apparent; the Silesian beet is the one that best answers this purpose.

Before closing this chapter I will give two tables showing the value of the different parts of the beet and the value of the beets at the different periods of its growth.

Head of the root	9.38 per cent of sugar.		
Other portions	13.13	"	"

If the large quantity of hurtful matters contained in the outside of the beet is taken into account, it will be seen how much less is its value than the other portions.

Quantity of sugar, in a hundred beets, during t

different periods of their growth and the corresponding weight of the roots.

20 July	5	2½ oz.
9 August	5,8	10 "
31 August	8	1 lb. 4 "
13 September	10	1 lb. 8 "
20 September	10,5	1 lb. 9 "
16 October	12,4	2 lbs.

§ Harvesting the Beet.

The beet in ripening gains its maximum of richness in sugar. Then is the time to take it up, to pull it out. This ripeness, which comes about the end of September or middle of October, manifests itself by the yellow appearance of the leaves, which get covered with red or brown spots and droop. To pull up the beets, a fine dry time is chosen, care being taken that the beets have previously had a ew dry days so that the skin be less watery and nore firm. The beets will only increase in value f they remain later in the ground, as long as the hermometer does not decrease to 40°.

The beets are taken up with a spade or plough ; hey are lightly shaken to take off the larger part of e adherent earth, and the head is cut off with a arp knife. Until they can be carted away, they e placed in small heaps or in lines on the ground, d are covered with the leaves that are cut off.

When pulling up or carting the beets, great care

must be taken not to bruise or wound them, as it would tend to their being spoilt on being kept.

Beets should be kept secure from frost, for manufacturing purposes. This root is very susceptible to cold and it deteriorates if exposed to a temperature higher than 40 degrees; at 45° and 50° it germinates. Frost softens the beet and destroys its sugar. A frozen beet stays good, as long as it is not thawed, but as soon as this sets in, the beet is useless for manufacturing purposes.

In Belgium and in France, beets are kept in pits: For this purpose, a ditch is dug in a dry place, 4 feet in depth and 5 feet in breadth, with a varying length. Along the bottom there is a drain to air the pit and drain off the water. The ditch is covered over with long beets, and the pit is then filled up with the roots, the top being arranged in the form of a roof about two feet above the level of the ground. The upper part is covered by about a foot of earth and it is smoothed down with a shovel. To ventilate the pit chimneys are placed at the ends or at regular distances, connecting with the drain, and these may be closed at pleasure.

Beets are often kept in the open air in heaps 5 or 6 feet in height and of irregular lengths and widths, ventilating shafts being set up, and the heap is covered with a layer of bad hay, and at the time of the frosts, a thick coating of earth is laid against the end walls.

But these precautions would be insufficient in this country to ensure the beets against the rigor

of the season, and it is absolutely necessary to have recourse to the plan in use in Russia, of keeping them in cellars. If the expense of this method is a little high, it also economizes considerably the cost of labor and further insures that the beets are better kept, as they can be daily watched. I saw, in 1874, at Cobourg, Ontario, a similar system which fully answered the purpose, and the beets that I saw, at the end of March, were in a perfect state of preser vation, which is almost unheard of in France, at such an advanced period.

§ 9 Value of the Beet.

A beet is all the better for being regularly grown, that is to say sown in a proper field, properly prepared, and that the season has been favorable to its germination, growth and maturity.

Beets grown in wet lands, immediately after fresh and too heavy manuring are larger, but they are far from having the same value as beets grown in drier lands and after a crop of corn has been raised between the manuring and the crop of beets. They contain relatively more water and foreign matter and less sugar. A rainy season also favors vegetation, but only gives very watery beets, rich in foreign substances but poor in sugar.

Among the foreign matters, contained in beets and which must be considered in the manufacture, are azote substances and alkaline salts of potash and soda which flow with the juice as well as the sugar. Saline substances do not destroy the sugar but pre-

vent its crystallization. We will see that the elimination of these substances is the greatest difficulty to be encountered in the extraction of sugar from beets. Beets for manufacturing purposes are better in proportion as they give a juice, richer in sugar, as compared with the amount of juice and also to the quantity of soluble matter which is contained in the juice.

I here give a table showing the composition of the beet at the various periods of its growth and maturity.

TABLE *of the matter contained in the beets in an acre of land; at the various periods of their growth and maturity, calculated in pounds.*

	Azote substances.	Cellular.	Sugar.	Mineral substances.	Various substances.	Total.	Water.	Weight of beets.	Rate per cent of sugar.
July 30.....	66	37	145	26	82	356	2310	2666	5.
August 9...	239	128	582	86	231	1266	9077	10343	5.8
" 31...	445	246	1727	197	343	2958	16972	19930	8.7
Septemb. 15	571	408	2440	202	245	4066	20000	24066	10.
" 30.	679	679	3203	209	387	5150	23315	28465	11.5
October 16..	736	921	3891	214	398	6029	25371	31400	12.4

I must here add a few observations concerning the keeping of beets.

After being taken up they are left for a few days on the ground, in heaps covered with leaves, before being carted away. This is done so that they may lose a certain portion of their heat and be less exposed to ferment in the heaps. Too much care cannot be taken of beets, when in heaps. They should be properly ventilated so as not to become heated, but care must be taken not to open the ventilating shafts, except when there is no danger of frost getting in to the heaps. In France, after January, the beet wakes up and has a tendency to grow and consequently it gradually loses its value as this vegatation is at the expense of the sugar itself. All manufacturers thus so regulate their work, so as to finish by the commencement of the new year, that is in three months. In Canada, beets can be very well kept until the end of March, without any great loss, so that with a factory fitted up similarly to those in Belgium and France, double the quantity of sugar could be here manufactured. Every one will understand the advantages thus derived. Instead of being prejudicial, the long winter of this country will thus really become an advantage.

With proper care, beets in heaps are seldom heated or fermented. If this does occur, the evil should be immediately remedied, if it is only local, by removing the beets where fermented and culling out those already commencing to spoil.

§ 10. PRODUCTION OF THE SEED.

The beet is a biennial plant, that is, it only com-

pletely finishes its vegetation in two years, and it is in the second year that it bears seed.

A great number of different varieties of beets are met with whose general qualities do not change, so that fodder beets do not because sugar beets and vice versâ.

If seed of the sugar beet is wanted to be reproduced, the best sorts must be selected, at the time of harvesting the crop of the first year, and these must be carefully preserved. This choice must be regulated by the form and nature of the root.

Beets are chosen that have the following characteristics, tap rooted, clean and with a resemblance to a pear.

Leaves crisp and serrate, and not too numerous.

A medium size.

A specific gravity relatively high.

The beets, whose head rise as little as possible above the earth, should be chosen.

When the beets are being taken up, the different corn sowed fields, which appear to have succeeded the best and which give beets very rich in sugar should be visited. Sandy clay lands in good heart, which have not received a fresh coat of manure immediately before the beet crop, give the best beets for seed. Having made a proper choice, one of the hands is stationed to overlook the taking up and picks out and lays aside those beets which seem to be most favorable for the object in view. Great care should be taken not to hurt the roots, and the leaves

only are to be cut off with the knife by taking off the head without touching the flesh of the beet. These beets are then carefully placed in pits or in cellars and withdrawn the following year, to be replanted.

The land to be used should be a good beet land prepared as for sowing. It should be in good heart, but should not be strongly manured, as a strong manure would induce too quick vegetation, which would retard the ripening and render it unequal. Good compost and lime will do perfectly well, if applied before transplanting, the lime to be lightly turned in with the harrow. The beets are then planted in squares, with a distance of two and a half feet between the rows and two feet in the rows, so that there will be about 3200 plants in an arpent. It is well to cover lightly the head of the root with earth.

One thing that must be particularly guarded against, is that there should not be in the vicinity, any field sown with seed bearing fodder beets, for the wind alone might bastardize the kind and take away the greater part of its value.

When the seed is ripe, which is recognized by the brown tinge, taken by the extremities of the stem, the plants are cut and laid carefully on the ground to finish the drying, they are then beaten with the flail or otherwise.

The seed is then cleaned and placed in a dry place secure from mice, to be kept.

Each stock of seed bearing beets will give about

a half a pound of seed, say for one arpent of 3200 feet, 1600 pounds. If we calculate the value of this seed which in France averages 100 *francs* for 100 *kilos* or 9 cents per pound, the crop will be worth $144.

The cost of production, &c., amounting at the most to $44, leaves a clear profit of $100 per arpent.

§ 11. ECONOMICAL CONSIDERATIONS.

Before terminating this important chapter, on the cultivation of the sugar beet, I will present a few economical considerations.

Admitting that the sugar industry be established in Canada, the culitvation of the sugar beet itself for manufacturing purposes will pay those who engage in it. To establish this, it will suffice to give a table showing the expenditure necessitated by its cultivation and to compare the expenses with the receipts.

An acre will yield from 16 to 20 tons of beets, with their heads off, or 640 to 800 bushels at the rate of 40 bushels to the ton. These beets could be sold to the factories at the rate of $4 a ton or 10 cents a bushel.

This is the average price paid in the different countries in which the sugar industry is established, and is in fact the real value for manufacture, so that this price could hardly be increased without gravely compromising the interests of the manufacture and even perhaps its existence; and since the sugar industry is called upon to assist the agricultural, the

latter must not by ex-aggerated notions render this impossible.

Let us suppose the average yield to be 18 tons or 720 bushels; at 10 cents per bushel the receipts would be $72.

Rent, manure, preparation of the soil...	$12.00
Seed 14 lbs. *a* 18 cents.................. ...	2.10
Sowing, hoeing, transplanting, planting out	8.00
Taking up.................	6.00
Cartage	6.00
Total expenditure..................	$34.00
Balance................	37.90
720 bushels of beets *a* 10 cts................	$72.00

We therefore have a clear profit of $37.90.

It is to be noticed that I include in the sum of expenses, the rent of the land, manure, preparing the soil, expenses which are the same as for cereal crops or for potatoes. The sum of the other expenses is no doubt less for other crops, but these will be more than compensated by the high figures of the receipts.

As to establishing the price of 10 cents per bushel, it has often been objected that in the town markets table beets are sold at a much higher price. This is perfectly true, but the production of sugar beets for manufacturing purposes, does not belong to market gardening as that of table beets, but to growing on a large scale. In fact, it will not require less than 5 or 600 acres of beets to supply one factory, whilst

the crop from 10 acres of red beets is probably more than sufficient to supply the whole of Quebec city. On the other hand, those who have a little experience in this matter very well know that where 700 bushels of sugar beets could be raised, 300 bushels of red table beets could not be grown.

An equal basis of comparison cannot then be established between these two products, destined for such different purposes.

If beets are considered as fodder for cattle, so as to determine their value, experience has shown that 1000 pounds of good hay are equal to 4000 pounds of beets or 71 bushels as a nutritive agent. Hay is sold on an average at $10 per 1500 pounds, (100 bundles) the equivalent in beets of these 1500 would be 6000 pounds or 107 bushels and we would thus have a comparative value a little over 9 cents per bushel.

On the other hand, the culture of the sugar beet is not in any way intended to supplant any of the other usual crops; it should take its place in the rotation and tend to the establishment of a regular system of rotation of crops, and it is destined to improve the whole agricultural system by the special care which it requires.

After the crop of beets, the heads that have been cut off with the leaves remain on the ground. These may be taken, for an average crop, as weighing 10,000 pounds.

This refuse is always ploughed into the land and

thus forms a natural manure. But, when required, they can be fed to the cattle or the cattle can be pastured on them as they are. Their nutritive value is one sixth that of good hay; so that 10,000 pounds of this waste used in this way, would equal 1600 pounds of hay.

By what precedes, the importance of introducing the sugar industry can be seen, in an agricultural point of view and the great advantage to be derived from its establishment. This importance and these advantages should of themselves stimulate farmers to make serious attemps to plant beets, even although factories have not as yet been established. They would thus know what to depend up on, as to the return to be received, when they are established, and in the meantime their efforts would not be lost, as they would always have as a crop, a fodder root whose nutritive value would recompense them for their labor.

I conclude by repeating that the land of Canada requires only a little effort, work, courage and activity on the part of its farmers to secure to them a fortune. Let them sincerely advance in the way of progress, and they will soon see their fields covered with rich harvests, their stables filled with fat cattle, their hovels changed into small chateaus, and their empty coffers overflowing with dollars. My prediction is by no means hazardous; I have seen the same things happen in other places.

SECOND PART.

MANUFACTURE OF BEET ROOT SUGAR.

CHAPTER FIRST.

GENERAL REMARKS.

The second part of this work is divided into three chapters, subdivided into sections.

Although my work is intended specially for those who have not made special studies, I think it my duty to include a few ideas on chemistry, which I will endeavor to bring within the comprehension of all those who may read it. These explanations are, at any rate, requisite for the necessary understanding of this part of my work.

§ 1° ELEMENTARY IDEAS ON CHEMISTRY.

Every thing that can be perceived by the senses is called a *body*. Bodies are solid, liquid or gaseous.

Atoms are infinitely small particles which have altogether the identical properties of the body itself, and which together compose the body.

Solid bodies are those whose molecules cannot be

separated, except by the use of more or less force : example : *sugar*, *iron*.

Liquid bodies are those whose molecules do not particularly adhere together, but move over one another and are separated without effort. Ex. *water* and *alcohol*.

Gaseous bodies are those whose molecules, far from adhering, have a tendency to separate and to fill a larger space. Ex. *oxygen*, *air*, *steam*, *carbonic acid*.

Bodies are *simple* or *compound* : they are simple when composed of only one element ; such as *oxygen*, *hydrogen*, *azote*, *carbon*, *chloral*, *sulphur*, *phosphorus*, *potassium*, *sodium*, *calcium*, *iron*.

Bodies are *compound*, when composed of the junction of two or more simple or compound bodies commingled together. Ex. *water* is composed of oxygen and hydrogen ; *carbonic acid* of oxygen and carbon ; *sugar*, of carbon, hydrogen and oxygen ; *lime* of calcium and oxygen ; *carbonate of lime* or lime-stone, of lime and carbonic acid. These compound bodies have special properties different from those of the simple or compound bodies which compose them.

Affinity is the property of bodies to combine and form other bodies ; it is this property which gives carbonic acid a tendency to combine with lime to form corbonate of lime.

Cohesion is the property which retains atoms to one another in solid bodies.

Solubility is the property of solution, possessed by

bodies, of melting in liquids, to form a mixture and not a combination ; for in combination, bodies unite to form other totally distinct bodies, and in a mixture, the bodies although intimately bound up retain their own properties, that is do not change their nature.

Oxygen unites with different bodies to form *acids;* with sulphur it forms sulphuric acid, with carbon, carbonic acid. Acids redden the blue tinge of litmus.

In uniting with other bodies, it forms *oxides* as lime, potash, soda, composed of oxygen, and calcium, potassium and sodium.

These latter bodies are called *alkaline bases* and are the bases of *alkaline salts.* They bring back to litmus the blue color, reddened by acids.

Acids and oxides unite to form combinations, which are called *salts.* Ex. limestone or carbonate of lime, carbonate of potash and of soda are the results of the combination of carbonic acid with lime, potash and soda.

Sugar sometimes acts like an acid and unites with lime to form *sugar of lime.*

Bodies are dissolved, are melted in liquids and form *solutions.* Sugar dissolves in water.

The *solution* of a body is called *concentrated*, when the liquid which contains it, contains all of the body, that it can dissolve and no more than it can dissolve, at a given temperature. In this case the liquid is said to be *saturated* with the body held in solution.

Thus we say a concentrated solution of sugar in water, or water saturated with sugar.

At a temperature of 58° Fahr., water dissolves three times its weight of sugar. The higher the temperature is raised, sugar becomes more soluble; so that at boiling point, that is to say at 212°, water dissolves six times its weight. Pure alcohol does not dissolve sugar, but ordinary alcohol, at 85 per cent of pure alcohol, and 15 of water, dissolves one fourth of its weight.

This property in sugar of dissolving in water, in greater or less quantity, as the temperature is more or less elevated, brings us to the *isolation* of sugar when dissolved; and as this is one of the general principles upon which the manufacture rests, I shall enlarge upon it.

I have just stated that water is saturated with sugar (or with any body whatever) when it dissolves all that it can contain. If we have 100 pounds of water saturated with sugar at boiling point, this water would contain 600 pounds of sugar in solution. Let our solution cool down to 58° Fahr and notice what occurs; at this temperature over 100 pounds of water will hold in solution 300 pounds of sugar, and can only hold these 300 pounds. We would then have 300 pounds of sugar not in a state of solution. These 300 pounds of sugar become deposited in the liquid in the shape of crystals, and if we were to drain off these crystals, if we were to dry them, we would have 300 pounds of dry sugar, that is to say one half of that which the water contained

at boiling point, and the other half still in the liquid. If we wish to gather the rest of the sugar, we would raise the temperature of our solution again to boiling point, then by evaporation we would bring it back to a state of concentration. Cooling would give us 150 pounds of sugar.

A further evaporation of 25 pounds of water would give 75 pounds of sugar, and so on.

By continuing this process, all the sugar contained in a solution of *pure sugar* is extracted.

Notice that I have underlined the words *pure sugar*, designedly. In fact, a solution of sugar may contain certain foreign substances which more or less retard crystallization, and this is the case, as will be seen further on, with the juice of the beet. This does not occur in making maple sugar, as the sap of that tree is a solution of pure sugar. In this latter case the temperature of the juice of the maple is raised until it no longer contains any vegetable water, so that in cooling it gives a solid mass of very small crystals, without even a drop of syrup.

Sugar crystals are much increased in size if they are formed by a slower cooling and from a weaker solution. This explains the fineness of the grain of maple sugar in cakes. By proper processes, grains as large as those of candy could be obtained, or grains similar in size to those of loaf sugar.

The details just given explain what takes place in evaporating the juice and boiling the sirup, and will facilitate the understanding of these operations, when explained.

§ 2. COMPOSITION AND DECOMPOSITION OF BODIES.

We have seen that simple bodies combine to form compound bodies (acids and oxides) and that these latter combine to form other more complex bodies called *salts*, as *carbonate of lime*, *sucrate of lime*. We will see that one of the most important operations in the manufacture of beet root sugar, the purifying and clarifying of the juice, depends on these principles.

All my readers have observed another phenomenon, by which two compound bodies in solution in a liquid may act one upon the other, not to combine together, but each to take from the other one of its elements and to form new and distinct bodies· This is often done, when an acid is placed in contact with a salt and that the *base* of this *salt* has more *affinity* for the other acid than with which it is in combination. This is every day noticed in the manufacture of gaseous waters. It is known that the distinctive quality of this water is carbonic acid, retained in solution in water. To produce this carbonic acid gas, water is dissolved in *tartaric acid* and *soda* or carbonate of soda, tartaric acid has more affinity for soda than carbonic acid, that is to say, it has a greater tendency to unite, to combine with this base. As soon as tartaric acid is found in presence of carbonate of soda in the solution, the latter is decomposed, the tartaric acid drives away the carbonic acid and takes possession of the principal ingredient, and forms *tartrate of soda* and the

carbonic acid gas is liberated and mixes with the water. The reaction becomes apparent by the effervescence of the liquid, due to the bubbles of carbonic acid that have been liberated.

One stage in the manufacture is explained by this fact, which is the principal basis of our system of working.

As will be afterwards seen, beet juice contains, in addition to sugar and water, different foreign substances which must be first eliminated, as they tend to decompose and to destroy the sugar and prevent it from crystallizing. These substances are first azote matters, as albumen, which destroys the sugar by causing fermentation; coloring matters and different substances held in solution in the liquid. There are also salts of potash and soda of which we will speak later.

To purify the juice, milk of lime is used, which, under the influence of heat, decomposes, destroys and precipitates the azote principles and coloring substances, in an operation which we call defecation

We have also seen that sugar forms with lime salt called sucrate of lime.

When the juice is to be purified, it is mixed with a quantity of lime sufficient to combine with the sugar and an excess of lime capable of having complete action over all the foreign azote substances The sugar is thus detached and the action of the surplus lime on the foreign substances produces all its effect. But the action of the lime cannot be pro-

longed the purifying, and beyond it must be detached from the sugar for which purpose the action of carbonic acid must be employed, which has a greater affinity for lime than sugar. To effect this, a current of carbonic acid is directed into the liquid mass which takes up the lime and forms with it carbonate of lime. This carbonate, when being precipitated to the bottom of the vessel in which the operation is carried on, draws with it all the impurities contained in the juice and when settled, leaves the latter colorless and limpid on the top of the muddy deposit of carbonate of lime and decomposed matter. This juice then only contains sugar and salts of potash and soda, and a small portion of organic matter which escaped the action of the lime.

In establishing this new principle which serves as a basis for the manufacture, I wished to avoid entering into embarassing details, when explaining the purifying process. To complete my explanations I will show the manner in which carbonic acid is manufactured.

§ 3. PRODUCTION OF CARBONIC ACID GAS.

To prepare carbonic acid for manufacturing purposes, lime stone or carbonate of lime which is composed of 56 parts of lime and 44 of carbonic acid is used.

This preparation is made by decomposing lime stone by heat. It is simply the preparation of lime, with this difference, that the gas produced during the operation is collected. Thus at the same time,

both the lime and the carbonic acid which are to used is prepared.

A kiln of mason work in form of a cone is used, with a height of three or four times the diameter of the base. At the apertures, there are two furnaces communicationg with the interior by two square bases; at the base also is a hole to discharge the kiln. The opening at the top is hermetically sealed by a cap of cast iron with a tube to which is fitted a pipe of from 8 to 10 inches in diameter, through which the gas escapes into the cylinder of the pump, which sends it into the juice to be operated upon.

The kiln is charged from the top, by first throwing in broken sticks, faggots, then alternately, the lime broken in small pieces and coke in the proportion of one tenth of the latter. When completely charged, fire is set in both furnaces, but the cap is not closed until the operation is well under way, that is to say during two or three days. The fire in both furnaces must be carefully kept up. When the operation is well under way, the upper part is closed, so that the air is excluded, the openings or cracks are closed with soft clay, and the draft is regulated by the pump which draws the gas produced by combustion and calcination.

As the carbonic acid gas is not pure when leaving the kiln, it, before reaching the pump, traverses a washing apparatus, which frees it of its impurities.

The daily consumption of lime stone for a factory

working 200,000 pounds of beets in 24 hours, is 10,000 pounds or 5 per cent, and that of coke for charging and for the two furnaces is 200 pounds. Of course the coke may be wholly or partly replaced by wood, if for economical reasons it may be deemed necessary.

I will add, so as not to have to return to this subject, a few words on the preparation of the lime for purifying.

§ 4. PREPARATION OF THE MILK OF LIME FOR PURIFYING.

This lime is first carefully slacked in a basin, and the thick milk is passed through a sieve of wire cloth which retains the pieces of uncooked stone or coals that might be in it, then the milk is put into another basin to such a thickness as that it may mark 20 degrees on the Beaumé areometer. In this state it is ready for use. Before using it, it must be well shaken so as to put all the lime which has a tendency to precipitate rapidly, in suspension.

The milk of lime contains one ounce of quick lime per gallon and degree Beaumé, so that our prepared milk contains 20 ounces.

§ 5. PURIFICATION OF JUICES AND SYRUPS.

When the beet juice has been treated with lime, it is freed from the greater part of the foreign matters contained and specially those which are more directly hurtful to sugar. These are the azote matters which, if their action is not destroyed as soon as the

juice is extracted from the beet, would act indirectly on the sugar, destroy it without delay and hurt the manufacture. There are other substances not attacked by the lime whose action does not immediately seem hurtful to sugar, and which do not prevent manufacture, but which later prevent part of the sugar from crystallizing, without thereby destroying the sugar, but which entering into the crystallized sugar, causes it to be less valuable. These are alkaline salts, or salts of potash and soda. Although, as I have stated, these substances do not appear immediately to affect the sugar, when it is not submitted to further processes, they may discolor the juice and the syrups, if a part of the sugar has been rendered useless for crystallization, either on account of the bad quality of the beet or for any other reason. In fact, it is admitted that a sucrate solution, containing liquid sugar, even in small proportion, is rapidly discolored, when boiled, when an alkali or alkaline salts are present. On the other hand these substances are more easily removed in the first stages of the operation and it is then that the syrups and juices must be freed from them.

To attain this separation, we have only one method, the use of *animal charcoal* or *bone black*.

But before enlarging on this subject, I will continue to give a few chemical explanations on sugar.

§ 6° OF SUGAR.

Sugar is specially qualified by its property of being decomposed, and reduced in alcohol and

carbonic acid by fermentation and it is the only substance, in nature, which possesses this quality. This decomposition takes place when it is in solution with 10 or 12 times its weight in water, when fermenting at a temperature of from 59° to 67° Fahr. and the solution is exposed to the air.

There are two kinds of sugar :

Prismatic or crystallized sugar.

Glucose or uncrystallizable sugar.

The first is extracted for manufacture in warm countries from the juice obtained by pressure from the *sugar cane* and in temperate regions from the *sugar beet*. It is also extracted in Canada and the Northern States from the sap of the *maple*. The second is met with in a great number of fruits, and especially in dried raisins, where it is found in its natural state. It is also produced by the action of certain acids on the starch of potatoes, the fecula of cereals and cellular tissue.

Crystallized sugar when acted upon by acids may be changed into liquid sugar or uncrystallizable but the latter can never be changed into prismatic sugar. Often, as in fruit, a sort of crystallization appears, but it is confused, and may in appearance be compared to the head of the cauliflower, whilst prismatic sugar shows regular crystals, in regular prismatic forms, and is best seen in the large crystals of sugar candi. I have stated that sugar is composed of carbon, oxygen and hydrogen. These elements enter into 100 pounds as follows :

Carbon..............................	42 lbs.
Hydrogen............................	$6\frac{1}{2}$ "
Oxygen	$51\frac{1}{2}$ "

At 59° F. sugar is soluble in one third of its weight of water. It melts and becomes liquid, when submitted to a high temperature and when cooling becomes a mass of confused crystals, as in loaves of maple sugar. If the temperature is raised a little, on being cooled it produces *barley sugar*, and finally if heated still further the mass browns and gives *caramel*.

By heating sugar, until completely burnt, it does not give cinders if altogether pure. This latter property is used to ascertain whether the sugar does not contain mineral substances.

When crystalized sugar is found in solution with organic substances it rapidly transforms into liquid sugar and is destroyed. This explains the necessity of purifying, immediately after extracting the juice.

A solution of *pure prismatic* sugar, containing lime, potash, soda, does not change even if the liquid is kept at boiling point. These substances, it is true prevent the sugar from crystallizing but they do not change it, so that once eliminated, the pure sugar remains and it can then crystallize.

But if the solution of sugar contains deteriorated sugar, or liquid sugar, then boiling in presence of alkaline matters will produce a color that cannot be removed and the sugar produced will be more or less dark.

These alkaline substances, lime, salts of potash and soda, prevent the crystallization of a certain portion equal to about 5 times their weight, so that, if beet juice contains 12 pounds of sugar and one half pound of these substances, the latter prevents 2½ lbs. of sugar from crystallizing.

Thus we have seen that sugar forms with lime a sucrate of lime: this sucrate contains per 100.

Lime....................................	14 parts.
Sugar	86 "
	100 "

This property as we have seen is used for purifying purposes.

§ 7. OF BEET JUICE.

Beets reduced to pulp and heavily pressed give about 80 per cent of highly colored juice. The average components of this juice are

Sugar....................................	12 lbs.
Azote substances..................	1¼ "
Salts......................................	¾ "
Water....................................	86 "
	100

The azote substances must be eliminated before the sugar can be extracted. Azote substances are for the greater part eliminated by the use of lime. But notwithstanding the care taken in purifying, a por-

tion always remains: there especially remains a coloring substance which darkens the juice in proportion as it is concentrated by evaporation.

On the other hand, the treatment of the juice by carbonic acid, is not so complete but that it leaves a certain quantity of lime. When the juice has been treated by lime and carbonic acid there still remains.

Some azote substances,
Some coloring matter,
Lime,
Salts of potash and soda.

So as to eliminate the greatest possible portion of these substances, the juice and syrup must be filtered in broken charcoal.

Charcoal in fact,
Takes away the azote substances,
Renders colorless the juice and syrup,
Absorbs the lime,
Absorbs the greater part of the alkaline salts.

I finish this section by giving the average composition of a sugar beet.

Sugar	12.00
Azote combinations	1.50
Ashes (salts)	1.00
Cellular and other matters	4.70
Water	80.80
	100.00

It then follows that in the pressed pulp there remains.

Sugar	1.00
Azote combinations	0.25
Ashes	0.25
Cellular and other matters	4.65
Water	13.85
	20.00

§ 8. OF ANIMAL CHARCOAL.

Of its manufacture and revivification.

Animal charcoal is obtained by calcining bones of animals in closed vessels until all the gases have escaped. The product of this calcining is a coal of a deep black, light, porous.

It is made in large kilns : and to calcine the bones they are broken and placed in cast or sheet iron pots, containing about one bushel. The pots filled with the bones are piled on the bottom of the furnace, so that they cover one another : the upper pots being covered.

In sugaries where they manufacture their own charcoal, they have kilns that can hold 100 pots or more, so that each kiln gives 3 or 4,000 pounds of charcoal. When the charge is complete, the fire is lighted and it is stirred so that are the pots gradually acquire a deep red tinge. Once the fire is going, an abundant quantity of gas is noticed coming out of the pots, arising from the organic substances in the bones.

The process going in inside is watched through a hole in the door of the kiln, and when it is observed that the gas has ceased escaping from the pots, the operation is finished. With a properly managed fire, it should take from 6 to 8 hours to complete the calcination.

For the charcoal to be good, it must be properly *burnt*; unburnt bones are easily noticed on account of their weight, which is greater and their density. The insufficiently burnt bones must be picked out and burnt over.

When an expert views new animal charcoal and has to test it at sight, he takes into account its weight, its color, which should be a fine dull black and at the same he should put a piece in his mouth. If the charcoal adheres strongly to his tongue and *bites* it, and if the color is good, he says that the charcoal is good.

Bones give about 60 per cent of their weight in animal charcoal.

When the bones have been calcined, the charcoal is not yet ready for use; it should be broken into pieces of about 3 or 4 eighths of an inch in diameter, this is done in a pounding mill. We then have what is called *noir en grains* (seed charcoal), and it is in this form that it is used to filter juice and syrups

Charcoal that has been used for filtering, should before being again used, be cleaned and revivified.

In fact it has absorbed from the juice and syrup certain azote substances, coloring matter, lime, salts of potash and soda, which must be taken out.

These substances are removed from it by hydrocloric acid, by fermenting it, washing it in hot water and by reburning.

The charcoal after being used six or eight hours in the filter is taken out and placed in cisterns of wood or masonry, and there covered with water mixed with a hundredth part of its weight of hydrocloric acid and it is left to itself for 8 hours at least. The acid then attacks all the substances absorbed by the charcoal, the azote substances, coloring matter, lime and salts and destroys them or renders them soluble. After eight hours the charcoal is drawn off and piled on the floor, or it is left another eight hours to ferment and is then washed in boiling water. The washer used is a semi cylindrical vessel slightly inclined, in which moves an archimedean screw. The charcoal is shovelled into the lower end and it mounts by degrees against a strong current of hot water. which comes down from the upper part. The hot water takes away all the impurities still in it. The charcoal when washed is placed in heaps on the floor to dry, then calcined and used again.

A factory working 200,000 pounds of beets per day uses 10,000 pounds of animal charcoal, say 5 per cent of the weight of the beets. The use of a larger quantity would be preferab e if economical reasons would allow it. To revivify this quantity of charcoal requires 100 pounds of hydrochloric acid. The stock of charcoal of such a factory would be from 30,000 to 40,000 pounds.

CHAPTER II.

DESCRIPTION OF THE MACHINERY.

So as to describe without interruption the processes of manufacture, in the folllowing chapter, I will in this one give a description of the principal machinery employed.

§ 1. BEET WASHER.

A wooden or iron cylindrical cage of 10 feet in length by $3\frac{1}{2}$ or 4 feet in diameter is used, immersed in water to one third of its diameter in a vessel, and driven 4 or 6 revolutions per minute. At one end there is hopper to receive the beets. Between the washer and the grater there is an inclined plane, with an iron or wooden grating on the side next to the washer.

The vessel is cleaned twice a day, and the water mixed with earth and rubbish runs into large vats in which the solids substances are deposited and make a good manure which is carefully gathered after the work is finished.

§ 2. GRATER AND ATTACHMENTS.

The grater is composed of a cast iron cylinder, with three disks grooved in the inside and two pulleys placed at the two ends of the shaft.

The cylinder is two feet in diameter by about two feet in length. The circumference is furnished

with saw teeth, separated by wooden brackets, three eighths of an inch in thickness which catch in the grooves in the disks. The grater when in position looks like a drum with saw teeth, appearing about one sixteenth of an inch above it. The beets go down the inclined plane and are shoved against the grater by an alternative motion by two mechanical pushers having a reciprocating movement of 10 to 15 revolutions a minute. The grater in movement revolves 800 to 1000 times per minute.

The grater is placed on a solid cast iron base and is covered with a movable sheet iron cap. On the upper part of the cap there is a small trench pierced with holes over the full length of the grater, which receives the water from a tap. This water spreads at pleasure over the grater when in action. Under the grater at each side there is a trough to receive the pulp.

§ 3. HYDRAULIC PRESSES.

The hydraulic presses are composed of a piston of one foot in diameter by three feet in height, sliding by friction in a cylinder; this piston carries a platform to receive the articles to be pressed. The piston is moved by a force pump whose piston is one inch in diameter.

The piston of the press lifts the platform between four strong iron pillars firmly fastened to the base, and to which apparatus there is a top or cap so that the articles are pressed between the platform and the cap. The diameter of the platform between

the uprights is 3 feet 4 inches, and the space between the platform and the cap 3 feet.

A factory fitted to make 200,000 pounds of beets has 8 hydraulic presses.

The pulp is taken out of the troughs by hand shovels or machine shovels and placed in woolen bags; the bag is placed on a table and the open end turned over and the pulp spread uniformly. On the top of the first bag there is placed a piece of sheet iron called a claie, then another bag and another *claie* and so on. When the pile is sufficiently high a workman called the *press-man* places the sacks and claies on the platform of the press. The load upon the platform being sufficient, movement is given it by starting the pump. Under the powerful action of the press the juice runs out, and reduces the pulp to twenty per cent of the weight of the beets. When the pressing is finished, the pump is stopped and the platform descends. A workman called the *depresseur* takes the sacks in which is the dry pulp, while the pressman takes his claies. The pressed bags are taken to a place where women or children empty them of their dry pulp by shaking them, then they are again used in the press until it is necessary to wash them.

The juice of the pulp runs by the trenches into a juice lifter.

§ 4. JUICE LIFTER.

The juice lifter is used to lift the juice by steam pressure. It is a cylinder of strong sheet iron, furnished at the upper end with a double tube for the

introduction and escape of the steam, a tube for the rising liquid and one to raise the juice. The two first, end on the inside of the top, but the pipe of the latter descends to the bottom of the apparatus. The juice lifter being full, the tap for the entrance of the liquid is shut off and steam is introduced, which pressing upon the juice, rapidly raises it by the flow pipe.

These machines by the rapidity and regularity of their working advantageously replace pumps for raising juices and syrups in a factory.

§ 5. BOILERS FOR DEFECATING AND CARBONATATING.

The juice lifter sends the juice into the boilers for defecating. These are four large vessels of sheet iron, nearly cubical. They are furnished witha steam coil for heating and another coil much larger which goes round the bottom and which is pierced through the whole length with small holes, for the purpose of injecting carbonic acid into the liquid. There are also two other boilers for the second *carbonatation or saturation.*

These boilers are furnished at the bottom with holes closed by taps for the escape of the liquid.

§ 6. DECANTERS.

These are similar vessels to the preceding, but not so large and without coils, in which the carbonated juice deposits its carbonate of lime and its impurities. The clear juice is decanted and the deposit is sent to *press filters.*

§ 7. PRESS FILTERS.

The press filter is an assemblage of trays formed of an exterior circle of cast iron and an interior disk of sheet iron pierced with holes; they are provided at the top with a hole corresponding to a service pipe. Of the two exterior trays which are full, one is fixed on a frame of cast iron, and the other is movable and works as also the pierced plates, upon two ears on two horizontal supporting arms. Each interior tray is furnished with a tap on its lower side, and a cloth is applied to the upper surface of each. These trays are tightened by means of a screw, so that there is a circular compartment on the interior between them communicating by the upper hole, with the service pipe and they are so adjusted by means of rubber washers that the apparatus is perfectly tight and all the compartments form filters. The deposit rendered muddy by the carbonatation is forcily sent up by the juice lifter, through the service pi e and fills all the compartments. Pressure compels the clear liquid to run out by the lower taps, whilst the carbonate of lime with all the impurities remains in the compartments nearly dry.

When the operation is finished, the trays are loosened, the cake that remains is let fall and the apparatus is fixed again for another operation. The cakes from the press-filters are a very fine manure which is carefully gathered. When the cloths are worn out they are replaced by others.

§ 8. FILTERS.

The filters are sheet iron cylinders of 10 feet in height by 2½ in diameter, with a bottom, but open at the top. In the rear they are furnished on a level with the bottom, with a *man hole* to empty them, and in front, by a tube communicating with a pipe with two taps, one on a level with the bottom for draining, and the other at the height of the charge in the filter for the running off of the filtered juices and syrups. This level of running off is necessary so that all the charcoal can be covered with the liquid and that the juice should prevent all contact between the exterior air and the charcoal, contact which might cause serious accidents. On the top there are several pipes which conduct the juice, syrup and hot water.

To charge the filter, a false bottom of pierced sheet iron is placed on a ledge about two inches from the bottom, and on this false bottom there is placed a cloth of light texture commonly called *bolting-cloth* ; then the charcoal is brought and regularly piled. At the upper part above the charcoal and at one foot from the top of the filter another bottom of pierced sheet iron is placed, and covered with another *bolting-cloth*.

I must add that every time a filter is emptied it should be carefully cleaned before placing new charcoal in it. The walls are scrubbed to remove everything that may have stuck to them and the bottom is washed with hot water ; then the walls

and bottom are sprinkled with milk of lime at 10 or 12° B.

This attention to cleanliness, which is easily done at any rate, is of the highest importance to the regular working of the manufacture.

The syrups evaporated, that is to say brought to 25° or 27° B first pass to a new filter, and the simple juice succeeds to the syrups.

§ Evaporating Apparatus.

This apparatus called a *triple effe,* is very difficult to explain without the machine itself in view. I will try however to give to my readers as exact an idea as possible. It is composed of three principal parts ; three boilers or chests, the safety columns, the condenser and air pump.

Before explaining the apparatus I will first explain the principle upon which it is based ; the rest will be more easily understood.

It is known that the air presses upon the surface of the earth and upon every thing thereon. The barometer shews the measure of this pressure.

We know that under atmospheric pressure (30 inches) water begins to boil a 212° Fahr. Juice boils at a temperature a little higher which increases as the concentration advances. To arrive at a sufficient concentration, the syrup should remain a considerable time under this high temperature, which is not without serious inconveniences for the sugar.

It has been noticed that if we could work in a

vacuum, boiling point could be reached at a lower temperature ; that the sugar could not then be damaged and the expense for fuel would be diminished.

To attain this object, vessels have been constructed that have no communication with the outside air, then a vacuum has been created in these vessels by pumping out the air they contained ; then to preserve the vacuum which would destroy the steam, the steam is condensed by cold water.

Such is the principle of evaporation at a low temperature in *vacuo*.

In using a series of vessels, in which the vacuum is successively increased, the steam produced by the working of the first vessel, may be sent to boil the second, which thus become the condenser of the first ; the steam produced by the second boils the third, which becomes the condenser of the preceding. Finally the steam produced by the boiling of the third passes into the condenser which liquifies there with cold water. This latter vessel is the only one that communicates with the air pump, which establishes the equilibrium of the vacuum in all the vessels.

The apparatus *a triple-effet* is thus composed of three boilers, or vessels closed from the exterior air. They are cylinders of cast or sheet iron of 4 feet in diameter by 8 feet in height. Each boiler has at its base a space shut off from the rest, which is called the *steam chamber*. The steam chamber occupies the whole space from one foot from the bottom to four

feet, and is consequently 3 feet in height. It is formed by two plates clinched to the body of the boiler and traversed through its whole length by vertical tubes of one inch and a half in diameter, which connect the lower part of the boiler with the upper part and serve to circulate the juice when boiling. The steam produced escapes by the top and is condensed in the chamber of the next boiler. The steam in the *chamber* circulates about these tubes, warms them and is condensed. The steam for the first comes directly either from the steam boilers, or the exhaust steam from the engine.

Each boiler is furnished with a steam gauge to ascertain the pressure and regulate the quantity of water to be used in the condenser, a thermometer for the temperature of the liquid, a steam gauge to indicate the inside pressure, a gauge to test the syrups, a spirit level, and a glass to watch the operation.

The three boilers communicate with one another by means of pipes, and on account of the difference of the pressure, the syrups flow of themselves from one boiler to the other. It may be supposed that the liquid passing successively through the three vessels is more and more condensed and arrives at the required state in the last.

Boiling is produced as follows :

1st	vessel	temperature	206°
2nd	"	"	185°
3rd	"	"	149°

Between the boilers there are *safety columns*

through which the steam for the *chambers* passes. The syrup in boiling sometimetimes escapes by the escape valve ; this syrup remains in the column and is taken up ugain. Without these columns, the syrup would be lost. A spirit glass shows the quantity in it.

§ 10. BOILING APPARATUS.

The construction and working of the boiling apparatus rest on the same principles as the evaporating machine ; I will not then have to enlarge on the subject. This apparatus is composed of the boiler, condenser and air pump. The heating is performed by three isolated superimposed coils. It is furnished with a taster which goes into the inside and by which samples of syrup are drawn out.

§ 11. TURBINE OR CENTRIFUGAL.

The turbine is a machine which is used instantaneously and mechanically to drain and dry the sugar, that is to say to isolate the crystals from the liquid. The construction of this machine is based upon this principle in physics : all bodies having a circular motion tend to fly off at a tangent from the centre. The turbine is composed of a drum open at the top, provided with very fine wire cloth on its inside surface. This wire cloth is fastened to a solid iron frame of sufficient weight to give considerable intensity to the centrifugal force. The drum is provided below with a pivot solidly fixed into a collar fastened into the base. This base serves as a covering for the drum.

The turbine in motion runs 1000 to 1200 revolutions per minute.

§ 12. AREOMETERS.

The Beaumé areometer is generally used to gauge juices and syrups. I have spoken of them in the introduction to this work. I give here a table of the graduation of this areometer, compared with that of Balling which indicates the percentage of sugar,and the centessimal areometer which shows the density.

Comparative tables of the Beaumé, Balling and Centessimal areometers.

Degrees Beaumé.	Percentage of sugar or degrees Balling.	Density of the liquid.	Degrees Beaumé.	Percentage of sugar or degrees Balling.	Density of the liquid.
0	0,00	1,0000	26	47,73	1,2203
½	0,90	1,0035	27	49,63	1,2308
1	1,80	1,0070	28	51,55	1,2414
2	3,59	1,0141	29	53,47	1,2522
3	5,39	1,0213	30	55,47	1,2632
4	7,19	1,0286	31	57,34	1,2743
5	9,00	1,0360	32	59,29	1.2857
6	10,80	1,0435	33	61,25	1.2973
7	12,61	1,0511	34	63,22	1,3091
8	14,42	1,0588	35	65.20	1,3211
9	16,23	1,0667	36	67,19	1,3333
10	18,05	1,0746	37	69,19	1.3458
11	19,87	1,0827	38	71,20	1,3585
12	21,69	1,0909	39	73,23	1,3714
13	23,52	1,0992	40	75,27	1,3846
14	25,37	1,1077	41	77,32	1,3981
15	27,19	1,1163	42	79,39	1,4118
16	29,03	1,1250	43	81,47	1,4267
17	30,87	1,1339	44	83,56	1,4400
18	32,72	1,1429	45	85,68	1,4545
19	34,58	1,1520	46	87,81	1,4694
20	36,44	1,1613	47	89,96	1,4845
21	38,30	1,1707	48	92,12	1,5000
22	40,17	1,1803	49	94,30	1,5158
23	42,05	1,1901	50	96,51	1,5319
24	43,94	1,2000	51	98,73	1,5484
25	45,83	1,2101	51½	99,85	1,5568

IMAGE EVALUATION
TEST TARGET (MT-3)

1.0 2.8 2.5 3.2 2.2 3.6 2.0 4.0 1.1 1.8 1.25 1.4 1.6

6"

2.8
2.5
3.2
2.2
3.6
2.0
1.8
1.0

CHAPTER III.

MANUFACTURE OF BEET ROOT SUGAR.

The details that I have given on some of the principles and operations attendant upon the manufacture of beet root sugar, and the descriptions given of the chief machinery in use, allow me to pass rapidly over the manufacture itself.

§ 1. Extracting the juice.

The beets are brought and placed as required in the washers. The workmen entrusted with this duty should carefully reject all beets that are spoiled, or those that, having been frost bitten are thawed ; as those beets contain principles that might ruin the whole work. They should also avoid allowing any hard substance to pass into the washer.

The rotary action of the washing drum plunged one third in water, causes the beets to rub against each other and against the walls of the machine and they are thus cleaned from the adhering earth. The beets arrive at the other end of the washer clean and are thrown on the grating of the inclined plane where they drain, and get rid of the small stones that may have come through with them. The beets are then sent against the grater, against which they are shoved by two pushers. The grater reduces them to a fine pulp which falls into the vessels below.

To assist the detaching of the pulp that may adhere to the grater, a continuous stream of water

from the tap on the cover on the top is directed to it, regulated by the quantity of beets used. The proportion of water is always 15 or 20 per cent of the weight of the beets. This water mixed with the pulp further assists the extraction of the juice by pressure.

The water added in the grater is always so regulated as to maintain the juices when leaving the presses at 6 or 6½ degrees Beaumé. More water is thus added if tne beets are rich, and less if the beets are poor in sugar.

The room in which the juice is extracted must be kept perfectly clean, without which fermentation would set in, which would ensure great loss. For this purpose every thing that touches the juice and the pulp is thoroughly washed four times a day, and twice a day sprinkled with milk of lime. The wollen bags used on the presses are also washed twice a day in hot water. On leaving the presses, the juice should be immediately treated with lime, so that it may not be spoiled, and it is sent by the *juice raiser* to the defecating boilers in the upper story. The charge of a *juice raiser* is the same as that of a boiler.

§ 6. DEFECATION AND CARBONATATION.

The juice sent up is muddy and of a dirty brown co r ; it fills about two thirds of the boiler.

The juice is heated to about 86° and whilst it is being heated there is added a quantity 6 hundredths of milk of lime at 20° Beaumé, that is to say for 500 gallons, the capacity of one of the boilers for the

daily manufacture of 200,000 lbs. of beets, 30 gallons of milk of lime at 20° B would be added. This is well mixed whilst the temparature of the juice is rising ; when the whole is well mixed a small injection of carbonic acid is directed into it. When the temperature has reached 131°, the injection pipe for the introduction of the carbonic acid is opened wider, this injection produces a great commotion in the boiler, to such an extent that it would overflow, if the man in charge did not *stir* it continually with a wooden rake, and throw in a little grease to stop the effervescing. It is on account of this effervescence that the boilers are only two thirds filled.

During this time the temperature slowly rises up to 176°, at which point the steam is shut off.

The carbonic acid is still continued to be injected until a small quantity of the juice on being drawn out, rapidly settles and gives on its surface a clear, limpid and slighty amber liquid.

When at this point, the injection of acid is stopped and the liquid is emptied into the decanting vessels where the clear portion is gradually drawn off.

This first operation has deprived the juice of the greater portion of the hurtful ingredients that the lime could eliminate, but to purify it as much as possible a second operation is gone through, which this time is carried on at a higher temperature The decanted juices are sent to the two last boilers to undergo a *second carbonatation* or *saturation*. The liquid being placed in one of these boilers 4 hun-

dredths of milk of lime at 20° B is added thereto, and is properly mixed, then carbonic acid gas is introduced. At the same time it is gradually heated up to about 200°. Again it is watched to notice the time when to shut off the injection of carbonic acid, and when it is seen that the liquid when drawn out is clarified instantly, the operation is complete. The carbonic acid is however left to act for a few minutes to ensure more complete success, then the injection of gas is shut off, and the liquid is boiled for a moment to drive off the excess of the carbonic acid retained and the juice is again sent to be decanted, the juice is this time sent to the filters.

The *froth* or deposits from the decantation pass by a juice lifter which sends them into the press filters.

The clear juice drawn from the press-filters goes through the second carbonatation.

§ 3. FILTERING.

The juice runs into the filter and fills it to the height of the overflow tap which is the same as the upper surface of the charge of the filter. In this manner is regulated the duration of the contact of the charcoal with the juice, which is an important point ; the animal charcoal acts not only as a mechanical filtering agent, but also as an absorbent, and the longer the contact of the charcoal with the juice is prolonged, the more does the charcoal produce its effects by absorbing the azote substances, coloring matter, lime and salts. The entrance and discharge of

the juice should be so regulated that the juice should take a half an hour in its passage through the filter.

Simple juice passes through a filter that has been used to filter syrup; it is thus enriched by the sugar left by the syrup on its passage. When the juice has passed 6 hours through a filter, the latter is considered as used up. It is then *scoured*, that is to say, hot water is put in which drives away the remaining juice from the filter, mixing more or less with it. When water has been placed in the filter, the juice comes out gradually less strong until it marks only ½ degree Beaumé. Then the upper tap is closed, and whilst letting the water run, the lower tap is opened. The water which then runs serves to give the charcoal its first washing.

The juice immediately after saturation has an amber color and a very marked taste of lime; when leaving the filter it becomes more clear and limpid, and has already a fair taste of sugar: in tasting it, a man unacquainted with the manufacture will recognize the presence of sugar, whilst he could scarcely do so by tasting the juice when leaving the presses or after defecation.

§ 4. EVAPORATION.

I have little to say concerning this operation, after the explanations given when speaking of the vaporizing machine. The juice comes to it at 6° Beaumé. It approaches up to 15° in the first vessel, up to 22° or 23° in the second and it is discharged

from the 3rd at 27°. As this syrup comes out of thi apparatus at the relatively low temperature of 149° and that the maximum effect of the charcoal is pro duced at an intermediate temperature between 160 and 190°, it must be heated to boiling point and ther sent to the filters.

Syrup at 27° B. contains 50 per cent of solid mat ters in solution and 50 of water.

In our factory working 200,000 pounds of beet per day, 25,000 gallons of juice at 6° B. are producec weighing at 1,0435 of density, 208,700 pounds. Thi juice contains:

Solid matters in solution.. 20,870 lbs.
Water ....187,830 " or 23,300 gals

To reach 27°, 167,000 pounds of water or 20,80 gallons have to be evaporated. There remains 41, 740 pounds of syrup at 1,250 of density or 420 gallons.

§ 5 SECOND FILTRATION.

The working of the second filtration is the sam as the first. The syrup remains in contact with the charcoal for half an hour. Each filter is used for 6 hours.

Four filters per 24 hours are always used, sc that two are always in operation, one for the syrup, the other for the juice, whilst the other two are used for cleaning and charging.

The syrup leaves the filter clarified and colorless,

and its taste in consequence of this operation is notably improved. It is deprived of the greater part of the organic substances that might be still contained in it, the lime and nearly all the alkaline salts.

When the filter has been used for 6 hours for the syrups, it is used for the juice which take up the remains of the syrup in it.

After the second filtration, the syrup is then purified as much as possible; it only contains water, sugar and a very small portion of salts of potash and soda.

The last concentration is then proceded with, the boiling down.

§ 6. BOILING DOWN.

We have seen that there remains 4200 gallons of syrup at 27° B. containing:

Solid matters in solution......	20,870 lbs.
Water................................	20,870 "

We must bring this syrup to such a point of concentration as that the sugar may crystallize. For this purpose we must remove still 94 per cent of the water which it contains, say 19,620 pounds or 2450 gallons and there will remain 1750 gallons of a boiled mass containing:

Sugar and some other substances...	20,870 lbs.
Water..	1,250 "
Say.................	22,120 "

In my calculations, I have not up to the present taken into account the substances taken off in the defecating and filtering processes and the losses in sugar. All these taken into account will reduce our 22,120 lbs of boiled matter to 19,000 pounds.

To reach this concentration, a vacuum is first created in the machine by the use of the air pump, and one half of the syrup to be reduced is put in ; then steam is let into the first coil and water is let run into the condenser so as to have the vacuum maintained at 24 inches corresponding to a temperature of 150° ; and the evaporation is continued until a sample taken up by the taster gives the *crook proof ;* to get this proof, a little syrup is taken up between the forefinger and thumb, which are then quickly separated ; if a very fine slight thread is formed which breaks and turns over upon itself in the shape of a *cork screw*, the right degree has been attained. Then the rest of the syrup is put in, two hundredths at a time (say in 25 times) as the mass reaches its proof point and the vacuum is maintained to 18 inches. Every time more syrup is introduced the mass must be brought up to the *hook proof.* As the second and third coils are covered, steam is necessarily introduced into them and the vacuum is gradually raised to 26 inches under a pressure of 50 pounds of steam. The operation is finished with 28 inches of a vacuum, that is a temperature of 130°, by reaching the *string proof*, which is arrived at when the thread in breaking no larger turns upon itself in the shape of a *cork screw.*

The operation of boiling down lasts from 7 to 8 hours. When finished, air is let in to the apparatus and the mass is discharged.

§ 7. Drying in the Turbines or Contrifugals.

The boiled syrup is run into reservoirs of the capacity of one boiling, in which it very soon becomes a crystallized mass. It has now only to be drained off and the sugar dried in the *turbine*.

As the mass has become nearly solid and would offer some obstacles to the draining, on account of the large pieces of sugar, it is passed through a crushing mill, where it is mixed with a small quantity of syrup raised to 30 or 32° B. Thus reduced into a sort of pulp, it is placed in the turbines. The charge for each turbine is 150 pounds. The machine is then started. The mass sticks evenly to the circular walls of the drum which stops the grains of sugar, but the liquid, driven by the centrifugal force, traverses the solid portion, which it clarifies by taking away its impurities, through the wire cloth and runs out into reservoirs. The machines are left in motion for a quarter of an hour.

The sugar has become dry. To whiten it, a stream of dry steam is directed into the drum for a few seconds, which completes the purifying of the crystals and renders them white. The turbine is stopped, and the sugar taken out and placed in sacks for transport or sent to the store.

Each operation thus gives 90 pounds of sugar,

and the day's work, that is, the 19,000 pounds of boiled stuff (1600 gallons) gives 11,400 pounds of dry sugar of the first strike, or sixty per cent of the boiled stuff or again 5, 7 per cent of the weight of the beets.

The syrup which runs from the turbine and which is called *raw syrup*, represents 40 per cent of the boiled stuff, or 7,600 pounds. By proper treatment this will produce another quantity of sugar. For this purpose, the syrup which gauges 44 to 46° is placed in a boiler and it is brought to 30° B by the addition of hot water, and it is clarified with bullock's blood, and powdered animal charcoal.

Clarification.—The syrup having been reduced to 30° B, ¾ per cent of bullock's blood is taken, say 3 quarts per every 100 gallons, which is diluted with 3 or 4 times its volume in syrup and emptied into the boiler. It is well *mixed* and 2 per cent of fine charcoal is added. This is well shaken to mix it, and the temperature is raised to 140°. It is heated until boiling point is reached. The albumen of the blood in coagulating, rises to the surface drawing with it all the impurities and leaves underneath a clarified syrup which is filtered in the same manner as the syrups at 27° and then boiled down. The syrup when boiled down takes two or three weeks to crystallize in vessels of a capacity of 4 or 600 gallons, placed in what is called *empli* in which a temperature of 95° is maintained.

The 7200 pounds of boiled stuff which we obtain will give, at 30 per cent, 2160 pounds of sugar of the

second strike and after being through the turbines, there remains 5040 pounds of syrup, which heated as before, gives 4800 pounds of boiled stuff which is left to crystallize during three or four months and will bring 10 per cent of sugar of the third strike, say 480 pounds.

The total result from the turbines as centifugals would therefore be :

From the	1st strike	11,400	lbs	of sugar	say	5.70 p. c.
"	" 2nd "	2,160	"	"	"	1.08 "
"	" 3rd "	480	"	"	"	24 "
		14,040				7,02

And there remains in molasses, reduced to the commercial standard, 42° Beaumé, 4500 pounds or 400 gallons.

Our whole production for 150 days work at 200, 000 pounds per day would therefore be :

$14040 \times 150 = 2,106,000$ pounds of sugar.
$4500 \times 150 =$ 675,000 " of molasses or 60,000 gallons.

Which would give a production per 100 of beets.
Sugar 7,02.
Molasses 2,25.

§ 8. Employment of Residue.

The residue from the manufacture of sugar is molasses, pressed pulp and manure.

Molasses.—Molasses contains sugar, water and nearly all the salts of potash and soda that have escaped the action of the animal charcoal: at 42° Beaumé its average composition is per 100 pounds.

Sugar	67 pounds
Salts and other foreign substances	12 "
Water	21 "

We have seen that these salts prevent a portion of the sugar from crystallizing: if they could be completely driven off, in an economical manner, nearly the whole of the sugar thus taken would be obtained; but as this cannot be done, the most advantageous use to be made of the molasses is to send it to the distiller, who obtains ther from alcohol and potash. 100 pounds of molasses at 42° give 4 gallons of spirit, and 10 pounds of saline matter (salts of potash and soda). On account of the large quantity of salts contained in it, this molass is unfit for alimentary purposes.

Pulp.—The pressed pulp is a valuable and easily kept food for cattle, who eagerly relish it. Its nutritive equivalent is 150, that is, 150 pounds of pressed pulp have the same value as 100 pounds of hay of good quality.

It is kept for use as required in pits dug in the earth, or in brick reservoirs, in which it is piled and it is covered so that it is sheltered from rain and frost. When getting old, it acquires a certain degree of acidity which makes it very agreable to cattle. It is sometimes given alone, but oftener mixed with chopped straw or hay.

The arpent giving 36,000 pounds of beets, the actory will return 20 per cent of pulp, say 7200 ounds equal to 4800 pounds of good hay.

The leaves and heads of the beets that have been ut off also furnish food for cattle. They give about 6,000 pounds per arpent. The alimentary equivalent being 660, these 10,000 pounds are equal to 600 pounds of hay, so that an arpent of beets, eturns to the farm a quantity of food equal in value o 6400 pounds of hay.

MANURES.—The manures furnished by the sugary onsist in the residuum from the press-filters and he deposits from washing the beets.

The first is composed of carbonate of lime and rganic matters decomposed and precipitated by the ime.

This substance constitutes a fertilizer and a manure, and is very well fitted for argilaceous lands. o with deposits from washing the beets, composed f earth and organic remains. These latter may be dvantageously employed when mixed with lime as compost.

§ 9. OLD PROCESS OF MANUFACTURE.

The explanations I have given have reference to he improved system of manufacture, now in general use. To conclude I will speak of the old system which will, perhaps, seem more easy to be understood, and which may be used by those who wish to experiment on a small scale.

The extraction of the juice, the filtering and purifying of the sugar are in the first place the same and the only difference is in the defecation, evaporation and boiling down.

The new system excels the old one, in that it is really more simple in practice, that it is more economical and that it gives better and finer results.

For *defecation* a copper boiler with a *double bottom* is used, in which the steam circulates. After each operation this boiler is carefully cleaned. For evaporating and boiling down, copper basins, with covers surmounted by chimneys for the escape of the steam generated in the boiling, are used. These basins are heated by steam in coils rolled at the bottom in spirals.

The *press-filters* are replaced by an ordinary screw or lever press.

As after defecation there always remains too much lime in the juice, the quantity of *animal charcoal* is increased to 15 and 20 per 100 of the weight of the juice to drive off this excess of lime.

Defecation.

The juice being brought to the boiler, it is rapidly heated up to 180°. Steam is then shut off and 2 gallons and a half of milk of lime at 20° Beaumé is put into 100 gallons of the juice ; it is well mixed with a *stirrer* and then slowly heated.

Under the influence of the heat and the lime, the organic substances contained in the juice are decom

posed and destroyed, the albumen that it contains is coagulated, and, rising in froth, it brings with it all the impurities. A large quantity of thick scum forms on the surface. About 205° the scum cracks and a clear juice is then seen. The heat is raised to boiling and the steam is immediately shut off. After a few minutes rest, the clear juice is first run off and sent towards the filters, then the scum, which is put into wollen sacks to be pressed. The juice from this pressing is put with the other clarified juice.

The clarified juice is limpid with a slight yellowish tinge.

Evaporation.

The filtered juice is by boiling in the evaporating basin reduced until it marks 27° Beaumé. If the boiling is too quick, if the syrup rises, the effervescence is quieted by throwing a piece of grease into the vessel. When required this is done when boiling down.

The syrup at 27° is filtered a second time and boiled down.

Boiling down.

Boiling down is the complement of evaporation. The concentration is continued until the *string proof* is attained. To establish this proof a little syrup is taken between the thumb and forefinger which are then separated. If the boiling down approaches its termination, a very fine thread is formed which breaks and returns on itself, twisting into the form

of a cork screw. We then have the *hook proof.* By boiling a little more, the *thread* no longer breaks or in breaking, it remains *unscrewed* and does not twist like a cork screw ; we then have reached the desired state and have the *thread proof.*

With the *hook proof* the mass still contains 10 per cent of water ; with the *thread proof* it contains only 5 per cent.

This is called evaporation and boiling *à air libre*, in opposition to the corresponding operations that I have already described, and which are called evaporation and boiling *in vacuo.*

Experiments on a small scale.

Those who wish to experiment on a small scale, should use this method, which is always the basis of the manufacture.

To extract the juice a screw or lever press is used. The same copper boiler would be used for defecation, evaporation and boiling down. As steam would not be at hand, a moderate open fire could be used so as not to burn the syrup.

In this case the turbine can not be employed, conical *moulds* like the sugar loaves of commerce are used, or rather boxes deeper than broad, having a spout on a level with the bottom. The moulds have also a hole at the pointed extremity. These openings being closed up, the boiled syrup is emptied into the vessels and they are allowed slowly to crystallize in a place heated to 80°. To obtain large crystals of

sugar, the syrup must not be boiled further than to reach the *hook proof.* Crystallization lasts 24 hours. After this time, the mould is placed in a room at the ordinary temperature, the bottom is unplugged and all the liquid syrup is allowed to run off. When the syrup has ceased running, a saturated solution of sugar in water is emptied on to the surface, say about a quart for three gallons of the stuff. This solution called *liquor* traverses the loaf of sugar, washes the crystals and drains off. It is left to drain perfectly, then the sugar thus obtained is dried.

Animal Charcoal.

To make the bone black or animal charcoal required for experiments in a small scale, a strong sheet iron pipe is taken, similar to those in use in houses for heating, a fixed bottom is fitted in and a movable cover; it is filled with broken bones and exposed to the moderate heat of a kiln. When no more thick smoke escapes the operation is finished. The pieces of bone that have become white by being too much burnt are rejected. The charcoal is reduced to small pieces, as small as possible by breaking them. To revivify it, it is allowed to ferment several days, it is washed with hot water and it is reburnt.

The filter is otherwise constructed as much as possible, on a small scale, in the same plan I mentioned in the second chapter.

§ Conclusion.

Beet root sugar manufacture cannot fail to prosper in Canada, when established, as it has prospered

in all countries where introduced. In fact it is not one of these chance industries where success depends a host of various circumstances.

The sugar factory supplies a commodity which is consumed in the very place of its production, and which is used all over the world. This commodity may be produced in Canada at as low a price as in any other country, which now supplies it. Why then give to others the profits on an article of consumption, with which we can advantageously supply ourselves ?

We now consume 80 millions of pounds of sugar, which we receive from the West Indies, the United States, England and France. When we have succeeded in manufacturing sufficient to supply our consumption, which increases every year, we would have in Canada one hundred factories which would use up 1,500 millions of pounds of beets, or the yield of 50,000 arpents, would give work in winter to 20,000 persons, and which would return a profit of more than three millions to the manufacturers.

A considerable revolution would be produced in agriculture ; great and heathy emulation will have started our farmers on the path of progress, and the lands of Canada, instead of remaining nearly unproductive by their unfitness for cultivation, will have rewarded their labors by giving them comfort and wealth.

Several other industries would derive the greatest advantages, which would also tend to increase the general prosperity of the country.

On this subject I will limit myself to saying a few words on the construction of the machinery.

The first factory must no doubt be put up by foreign builders who have made a specialty of the work, but very soon the builders of the country will have acquired the necessary experience and all that concern the building and repairing of machinery for sugar factories, will form a new branch of our national industry.

To conclude, I will add a few notes on the direct advantages presented by the establishment of a beet root sugar factory in Canada. And first I will reproduce the tables of the expenditure, receipts and profits from a sugary using 12,000 tons of beets in 100 or 120 days in the various countries in which this industry is now in a prosperous state.

EXPENDITURE IN FRANCS PER TON OF BEETS.

	Belgium and France.	Holland.	Germany.	Russia.	Italy.
Beets.	22.00	27.00	25.00	25.00	24.00
Labor.	4.20	4.85	5.50	6.75	5.50
Fuel.	3.12	3.78	3.41	5.00	4.86
Sacks and cloth.	0.50	0.50	0.50	1.25	1.00
Lime.	0.33	0.33	0.33	0.75	0.75
Lighting and boiling.	0.40	0.45	0.40	0.50	0.50
Management.	2.00	2.50	3.00	3.75	3.75
General expenses.	1.66	1.80	1.66	3.75	3.75
Reboiling.	"	"	"	5.00	5.00
Repairs.	1.00	1.20	1.00	3.25	3.25
Excise duties.	18.00	18.00	20.00	8.75	"
	53.21	60.36	60.80	63.75	53.36

RECEIPTS IN FRANCS PER TON OF BEETS.

	Belgium and France.	Holland.	Germany.	Russia.	Italy.
Percentage of produce in sugar.	6.4	7	8.6	7.6	6.6
Sugar.	64.00	71.00	76.92	83.75	71.30
Molasses.	3.50	3.50	2.80	2.50	2.50
Pulp.	2.00	3.00	3.00	2.50	2.50
	69.50	77.50	82.72	88.75	76.30

RECAPITULATION.

	Belgium and France.	Holland.	Germany.	Russia.	Italy.
Receipts per ton.	69.50	77.50	82.72	88.75	76.30
Expenses " "	53.21	60.36	60.80	63.75	52.36
Profit " "	16.29	17.14	21.92	25.00	23.94
" on 12,000 tons.	195.480	205.680	263.040	300.000	287.280

The establishment of such a factory requires a a capital of 600,000 francs in France, Belgium, Holland and Germany. In the other countries, when the machinery has to be imported, the capital may reach 750,000 francs.

A factory in Canada, might extend its working over 150 and even 175 days, and only use 70 or 75 tons of beets per 24 hours, in place of 100 or 120 tons, which would occasion a decrease in the price of the machinery.

In any case, I think that here a capital of $150,000 would be sufficient to establish a factory equal to using 12,000 tons of beets during the season, say the crop of 800 acres. The special machinery alone could be bought in foreign countries and the rest made here which, in addition to the advantages given to local industry, would save considerable expenditure for packing and freight. On the other hand, it would be the means of interesting our builders in the undertaking.

The machinery, buildings and immovable stock would cost $100,000, and there would remain $50,000 of floating capital.

The receipts from this factory would certainly be as great as in the countries above mentioned, as sugar is sold as dear here, and it has been proved that our beets are as rich and as good, as those of countries most favored in this respect.

The expenses of manufacture and especially those for labor would be much higher, for the first years, but this increase in the expenses would certainly not reach two dollars per ton of beets worked up, and on the other hand, we must consider that we are free from the excise duty which weighs so heavily on the net cost of the sugar in these other countries, which would more than compensate the difference.

We can therefore without any fallacy, count on a net profit of $4 per ton of beets, say nearly $50,000 on a manufacture of 12,000 tons, which would give a dividend of more than 30 per cent.

TABLE OF CONTENTS.

CHAPTER SECOND.

CHAPTER THIRD.